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# RULES AND REGULATIONS FOR THE CONSTRUCTION AND CLASSIFICATION OF STEEL SHIPS

## 1965

## METRIC EDITION

ENG.

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# REGISTER BOOKS AND OTHER PUBLICATIONS ISSUED BY THE COMMITTEE OF LLOYD'S REGISTER OF SHIPPING

**LLOYD'S REGISTER BOOK** (Volumes I, II and III issued annually in July; Volume IV in January).

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The Register is kept up to date by means of cumulative monthly Supplements containing the latest survey records for all classed ships, and changes of name, ownership, flag, tonnage, &c., for all ships, whether classed or not. Each Supplement is accompanied by particulars of new entries to the Register—that is, new ships and ships of which the names have been changed.

**A Weekly List of Alterations** in Volume I is also published.

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**VOLUME IV (Directory)** contains lists of shipbuilders with existing ships they have built; marine enginebuilders and boilermakers; dry and wet docks; telegraphic addresses and codes used by shipping firms; marine insurance companies.

**Statistical Tables** are issued gratis to Subscribers to the Register Book.

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Published annually in April, this volume contains in addition to detailed information relating to yachts classed by the Society, the names, dimensions, etc., of other British and overseas yachts, whose particulars are known; a list of one-design classes, and the sail numbers of certain classes of racing yachts; also, in an Appendix, particulars of Yacht and Sailing Clubs, with the names of Officers; yachts whose names have been changed; yacht builders and designers with the yachts they have built and designed, and a list of Yacht Owners with their addresses, Clubs and the names of their yachts.

The Sail Numbers section may be purchased separately.

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Reproductions in colour of Yacht Club burgees and defaced ensigns and the private signals of yachtsmen.

**REGISTER OF AMERICAN YACHTS**

This Register is published annually in May from the Society's New York Office. Copies may also be obtained on application to the Manager, Lloyd's Register Printing House, Manor Royal, Crawley, Sussex, England.

This book contains the names, dimensions, and full particulars of the yachts of the United States and Canada, so far as they are ascertainable; reproductions in colour of the burgees of yacht clubs and the private signals of yachtsmen; a list of yacht clubs with the names of their officers; an index of signal letters; late names of yachts; and a list of yacht owners of the United States and Canada, with their addresses, clubs and yachts.

Also issued separately:—

Club Burgees and Private Signals (in colour).

**RULES AND REGULATIONS FOR THE CONSTRUCTION AND CLASSIFICATION OF STEEL SHIPS**, which contain the following:—

| Chapter | |
|---|---|
| | REGULATIONS |
| A | General Rules and Regulations of Lloyd's Register of Shipping. |
| B | Classification Regulations. |
| C | Periodical Survey Regulations. |
| | CONSTRUCTION RULES |
| D | Steel Ships. |
| E | Pumping and Piping. |
| F | Fire Protection, Detection and Extinction. |
| G | Conditions for Survey of Machinery during Construction. |
| H | Main and Auxiliary Engines and Gearing. |
| J | Boilers and other Pressure Vessels. |
| K | Spare Gear for Steam and Internal Combustion Machinery Installations. |
| M | Electrical Equipment and Electric Propelling Machinery. |
| N | Refrigerated Cargo Installations. |
| P | Quality and Testing of Materials (including lists of Approved Manufacturers and Proving Establishments). |
| R | Provisional Rules and Guidance Notes: (A) Methane Gas as fuel for the propulsion of Methane Tankers. (B) Plastic Pipes. (C) Classification of Nuclear Ships. (D) Metal Pipes for Water Services. (E) Torsional Vibration Stresses and Critical Speeds for Main and Auxiliary Oil Engines. |

*A Metric edition of the Rules is also published*

**EXTRACTS FROM THE RULES:—**

| | CHAPTER(S) |
|---|---|
| No. 1 | B and C |
| No. 2 | B, C, E, F, G, H, J, K, P and R (A, B, D and E) |
| No. 3 | E, G, H, K, P and R (A, B, D and E) |
| No. 4 | J, P and R (A) *A Metric edition is also published* |
| No. 5 | F |
| No. 6 | M *A Metric edition is also published* |
| No. 7 | N (and Frozen Meat Stores) |
| No. 8 | P |

**STEEL TRAWLERS**

**YACHTS Vol. I:—WOOD AND COMPOSITE YACHTS (Sailing, Auxiliary, and Full Power)**

**Vol. II:—STEEL YACHTS**

**Vol. III:—INTERNATIONAL RATING CLASSES**

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**Volume II Metric Sections**
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**ANCHORS—APPROVED DESIGNS**

Comprising lists (1) in alphabetical order of Firms, (2) in alphabetical order of name (if any) of anchors, together with descriptive sketches. Revised and brought up to date, 1945.

**PROVISIONAL RULES FOR THE CLASSIFICATION OF NUCLEAR SHIPS**

**PROVISIONAL REQUIREMENTS FOR THE SURVEY OF PRESSURE COMPONENTS FOR LAND-BASED NUCLEAR INSTALLATIONS**

TERMS OF SUBSCRIPTION FOR THE REGISTER BOOKS AND PRICES OF OTHER PUBLICATIONS UPON APPLICATION TO THE MANAGER, LLOYD'S REGISTER PRINTING HOUSE, MANOR ROYAL, CRAWLEY, SUSSEX ENGLAND.

# LLOYD'S REGISTER OF SHIPPING

FOUNDED 1760

# RULES AND REGULATIONS FOR THE CONSTRUCTION AND CLASSIFICATION OF STEEL SHIPS

1965

METRIC EDITION

71, FENCHURCH STREET, LONDON, E.C.3

*Telephone: ROYal 9166*

*Telegraphic Address* { *Inland: Committee, London, Telex*
*Overseas: Committee, London, E.C.3*

*Telex No.: 24305*

501†

# CHANGES EMBODIED IN PRESENT EDITION OF THE RULES

**Additions and amendments which have been adopted by the Committee since the previous (1964) edition of the Rules will be found in the following Chapters:**

**Chapter B** — CLASSIFICATION REGULATIONS

**Section 1.** Para. 104 has been amended.

**Section 8.** Para. 808 has been amended.

**Chapter C** — PERIODICAL SURVEY REGULATIONS

**Section 2.** Paras. 207, 219 and 227 have been amended.
A new Section 4 (Liquefied Gas Carriers) has been added.

**Section 10.** This section has been revised.

**Section 11.** Para. 1102 has been amended.

**Chapter D** — STEEL SHIPS

**Arrangements to Resist Panting**

**Section 9.** Para. 908. A final sub-paragraph has been added.

**Machinery Spaces**

**Section 22.** New paragraphs (2216 and 2217) have been added.

**Hatchways and Deck Openings**

**Section 23.** New paragraphs (2309 and 2331) have been added.

**Bulwarks, Freeing Ports, Scuppers, Sanitary Discharges and Side Scuttles**

**Section 25.** A new paragraph (2521) has been added.

**Rudders**

**Section 26.** Para. 2604 has been amended

**Steering Gear**

**Section 27.** Paras. 2701 to 2708 have been revised.

**Masts and Rigging**

**Section 28.** Para. 2803 has been amended.

**Welded Construction**

**Section 31.** Para. 3106 has been amended.
A new paragraph (3107) has been added.
Paras. 3108 and 3109 have been amended.
A new paragraph (3110) has been added.
Para. 3128 has been amended.

**Equipment**

**Section 33.** Para. 3306 has been amended.

**Bulk Carriers**

**Section 37.** Para. 3704. **Table A** has been amended.
Para. 3705. **Table B** and Notes have been amended.
Paras. 3711 and 3726 have been amended.
A new paragraph (3732) has been added.
**Table 18.** Note 2(c) has been amended.

OIL TANKERS

**General**

**Section 40.** Paras. 4003 to 4012 have been revised.
Para. 4020 has been amended.

**Longitudinal Strength**

**Section 41.** Paras. 4104, 4105 and 4106 have been amended.
**Table 60.** This Table has been revised.
**Table 62.** A new Note 7 has been added.

**Shell Plating**

**Section 43.** Para. 4305 has been amended.

**Oiltight and Non-Oiltight Bulkheads**

**Section 50.** Paras. 5006 and 5021 have been amended.
Paras. 5032 to 5037 have been revised.

**Effective Section Modulus, Face Areas and Minimum Thicknesses**

**Section 53.** Paras. 5308 and 5309 have been amended.

**REQUIREMENTS FOR THE CARRIAGE OF LIQUEFIED GASES**

**Sections 71, 72 and 73.** The requirements have been expanded into three sections and the heading amended as above.

**Chapter E**

**PUMPING AND PIPING**

**Section 1.** Para. 101. The reference now amended to the "International Convention for the Safety of Life at Sea—1960".
A cross-reference to "Guidance Notes on Metal Pipes for Water Services" has been added.

**General**

**Section 2.** Para. 202. The reference now amended to the "International Convention for the Safety of Life at Sea—1960".

**Engine Cooling Water Systems**

**Section 8.** Paras. 802 and 805 has has been amended.
Para. 808. A cross-reference to "Guidance Notes on Metal Pipes for Water Services" has been added.

**Liquefied Gases**

A new Section 12 has been added.

**Chapter F**

**FIRE PROTECTION, DETECTION AND EXTINCTION**

**Part 1**

**General**

**Section 1.** Paras. 101 and 104. The references now amended to the "International Convention for the Safety of Life at Sea—1960".

**Part 2**

**Fire Protection in Passenger, Cargo and Other Ships**

Part 2 has been completely revised and the heading amended as above.

**Chapter H**

**MAIN AND AUXILIARY ENGINES AND GEARING**

The title of this Chapter has been amended as above.

**General Requirements**

**Section 1.** New paragraphs (105 and 106) have been added.

**Steam Reciprocating Engines**

**Section 2.** Paras. 201 and 202 have been amended.

**Turbines and Propelling Motors**

**Section 3.** This Section has been revised.

**General Requirements for Steam Reciprocating Engines and Steam and Gas Turbines**

**Section 4.** Paras. 405, 445 and 446 have been amended.

**Oil Engines**

**Section 6.** Paras. 601 to 625 have been revised.

**General Requirements for Oil Engines and Starting Air Compressors**

**Section 7.** Para. 725 has been amended.

**Chapter J**

**BOILERS AND OTHER PRESSURE VESSELS**

**Pressure Vessels for the Carriage of Liquefied Petroleum Gases**

**Section 25.** Paras. 2501 and 2504 have been amended.
Para. 2505. A cross-reference has been added.

**Chapter M** ELECTRICAL EQUIPMENT AND ELECTRICAL PROPELLING MACHINERY

**General Requirements**

**Section 1.** Para. 101. The reference in sub-para. (a) now amended to the "1960 Safety of Life at Sea Convention".
Paras. 108 and 111 have been amended.

**Distribution**

**Section 5.** Paras. 506 and 507 have been amended.

**Switchboards, Switchgear and Protective Equipment**

**Section 6.** Para. 601. Sub-para. (c) has been amended, and sub-para. (f) has been added.

**Lighting**

**Section 10.** A new paragraph (1004) has been added.

**Internal Communications**

**Section 14.** A new paragraph (1405) has been added.

**Special Requirements for Oil Tankers and Ships intended for the Carriage in Bulk of Liquid Cargoes having a Flash Point of 150° F. (65,5° C.) or less.**

**Section 16.** Para. 1609 has been amended.

**Trials**

**Section 19.** Para. 1904. The final sub-paragraph has been amended.

**Chapter N** REFRIGERATED CARGO INSTALLATIONS

**Tests after Completion**

**Section 5.** Paras. 503, 504 and 505 have been amended.

**Periodical and Other Surveys**

**Section 8.** Para. 806 has been amended.
A new paragraph (807) has been added.

**Chapter P** QUALITY AND TESTING OF MATERIALS

**Approval of Electrodes for Manual Arc Welding in Hull Construction**

**Section 15.** This Section has been revised under the above heading.

**Chapter R** PROVISIONAL RULES AND GUIDANCE NOTES

New Guidance Notes (D)—"Metal Pipes for Water Services" and (E)—"Torsional Vibration Stresses and Critical Speeds for Main and Auxiliary Oil Engines" have been added.

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**The above additions and amendments were promulgated in Notices Nos. 1 to 5. A number of alterations of a minor or editorial nature have also been made.**

R. B. NANCARROW,
*Secretary*

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# Chapter A

# GENERAL RULES AND REGULATIONS OF LLOYD'S REGISTER OF SHIPPING

## Section 1

THIS Society, founded in 1760 and reconstituted in 1834, was established for the purpose of obtaining for the use of Merchants, Shipowners, and Underwriters, a faithful and accurate Classification of Mercantile Shipping, and for the government of which the following Rules and Regulations have been from time to time adopted.

## Section 2

The superintendence of the affairs of the Society to be under the direction of a General Committee composed of Merchants, Shipowners, and Underwriters (twenty-four elected in London, namely, nine by the Committee of Lloyd's, twelve by the Committee of the London General Shipowners' Society, and three by the Committee of the Institute of London Underwriters, and thirty-seven at the principal Outports), and the following, namely:—Shipbuilders and/or Engineers, not exceeding ten, who may be elected by the General Committee; additional Members not exceeding twelve, who may be elected by the General Committee; past Chairmen, Deputy-Chairmen and Treasurers, and Deputy-Chairmen and Chairmen of the Sub-Committees of Classification of the Society, who may be elected by the General Committee, and the following *ex-officio* Members, namely:— The Chairman, or, in his absence, the Deputy-Chairman, of the Corporation of Lloyd's; the Chairman, or, in his absence, the Deputy-Chairman, of the London General Shipowners' Society; the Chairman, or, in his absence, the Deputy-Chairman, of the Institute of London Underwriters, and the Chairman of each National Committee established abroad.

The General Committee is further empowered to elect as Honorary Members of the General Committee such persons of distinction and eminence as the General Committee shall from time to time think fit.

Any Member (except an *ex-officio* Member, or a Member elected by the General Committee) who does not attend meetings of the General Committee for twelve consecutive months, without leave of absence, shall cease to be a Member, and his place shall be filled up in the usual way.

NOTE.—Official intimation to be given in June of each year whether the Chairman or Deputy-Chairman of the Corporation of Lloyd's, the Chairman or Deputy-Chairman of the London General Shipowners' Society, and the Chairman or Deputy-Chairman of the Institute of London Underwriters, are to be the *ex-officio* Members for the ensuing twelve months.

## Section 3

The General Committee reserve the right of varying or withdrawing the representation of Outports, and of Shipbuilders and Engineers; also the representation of Shipbuilders, Engineers, Steel Makers, and Forgemasters on the Technical Committee hereinafter mentioned, as well as the mode of election of Members.

## Section 4

1. Seven of the Members elected in London, namely, three representatives of Lloyd's, three representatives of the London General Shipowners' Society, and one representative of the Institute of London Underwriters, to retire annually by rotation, but to be eligible for re-election. The vacancies so arising to be filled by the election of three representatives by the Committee of Lloyd's, three representatives by the Committee of the London General Shipowners' Society, and one representative by the Committee of the Institute of London Underwriters.

2. Of the Members elected at the Outports twenty-one to retire at the end of four years, and seven of the Members elected at Liverpool and the nine Members elected at Glasgow to retire annually. The retiring Members are eligible for re-election.

3. All Members elected by the General Committee are to retire at the end of four years, and are to be eligible for re-election.

**Section 5**

The Committee to appoint Sub-Committees of Classification, to be so regulated that each Member of the General Committee may, in rotation, take his turn of duty thereon throughout the year.

**Section 6**

The Committee to appoint from their own body a Chairman to hold office for such period as they shall determine and two Deputy-Chairmen who shall be elected annually; one Deputy-Chairman being designated Deputy-Chairman and Treasurer and the other Deputy-Chairman and Chairman of the Sub-Committees of Classification.

**Section 7**

The Secretary, Clerks, and Servants of the Society, and the Surveyors, to be appointed by and be under the direction of the General Committee.

**Section 8**

Special meetings to be convened by order of the Chairman, or one of the Deputy-Chairmen, or on the requisition of any three Members.

**Section 9**

All elections and appointments to be made by ballot, excepting when, in the election of Chairman or one of the Deputy-Chairmen, only one person is nominated for each office.

**Section 10**

No Member of the Committee to be permitted to be present on the decision of the classification of any ship of which he is the owner, or wherein he is directly, or indirectly, interested.

**Section 11**

1. The Committee to be empowered to make such By-Laws for their own government and proceedings as they may deem requisite, not being inconsistent with the original Rules and Regulations under which the Society was established; but no new Rule or By-Law to be introduced or any Rule or By-Law altered, without special notice being given for that purpose at the meeting of the Committee next preceding that at which such motion is intended to be made ; such notice to be inserted in the summons convening the meeting.

2. No new Rule, or alteration in any existing Rule materially affecting the classification of ships, to be applied compulsorily to ships of which the plans have been submitted and approved before the expiration of six months after the date when the change has been adopted.

**Section 12**

A Register Book to be printed annually for the use of Subscribers, containing the names of the ships with other useful information, and the character assigned, where the ships are classed by the Society; also the names, etc., of ships of 100 gross registered tons and upwards which are not classed with the Society.

The terms of subscription to be such annual sum or sums as may from time to time be determined by the General Committee.

## Section 13

### TECHNICAL COMMITTEE

1. The Technical Committee to be constituted as follows:—

| *Ex-officio*— | Ship-owners | Under-writers | Ship-builders | Engineers | Others | TOTAL |
|---|---|---|---|---|---|---|
| The Chairman of Lloyd's Register ... ... | – | 1 | – | – | – | 1 |
| The Deputy-Chairman and Chairman of the Sub-Committees of Classification of Lloyd's Register | 1 | – | – | – | – | 1 |
| The Deputy-Chairman and Treasurer of Lloyd's Register ... ... ... ... ... ... | 1 | – | – | – | – | 1 |
| *Nominated by*— | | | | | | |
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| The Royal Institution of Naval Architects ... | – | – | 1 | 1 | – | 2 |
| The North-East Coast Institution of Engineers and Shipbuilders ... ... ... ... ... | – | – | 1 | 1 | – | 2 |
| The Institution of Engineers and Shipbuilders in Scotland ... ... ... ... ... | – | – | 1 | 1 | – | 2 |
| The Shipbuilding Conference ... ... ... | – | – | 5 | – | – | 5 |
| The National Association of Marine Enginebuilders | – | – | – | 3 | – | 3 |
| The Institute of Marine Engineers ... ... | – | – | – | 2 | – | 2 |
| The British Internal Combustion Engine Manufacturers' Association ... ... ... ... | – | – | – | 1 | – | 1 |
| The Society of Consulting Marine Engineers and Ship Surveyors ... ... ... ... ... | – | – | – | 1 | – | 1 |
| The Dry Dock Owners' and Repairers' Central Council ... ... ... ... ... ... | – | – | – | – | 2 | 2 |
| The Iron and Steel Institute ... ... ... | – | – | – | – | 1 | 1 |
| The British Iron and Steel Federation ... ... | – | – | – | – | 1 | 1 |
| The Federated Forgemasters ... ... ... | – | – | – | – | 1 | 1 |
| The Honourable Company of Master Mariners... | – | – | – | – | 1 | 1 |
| The Institution of Electrical Engineers ... ... | – | – | – | – | 1 | 1 |
| The British Electrical and Allied Manufacturers' Association ... ... ... ... ... | – | – | – | – | 1 | 1 |
| The Technical Committee ... ... ... ... | 3 | – | 2 | 2 | – | 7 |
| ,, ,, ,, (from other countries abroad) | – | – | – | – | 8 | 8 |
| | 10 | 4 | 12 | 14 | 16 | 56 |

The above nominations to be subject to confirmation by the General Committee.

In addition to the foregoing:—

(*a*) National Committees abroad may select representatives to attend meetings of the Technical Committee.

(*b*) Further persons may, with the consent of the General Committee, be co-opted to serve on the Technical Committee.

2. The function of the Technical Committee is to consider any technical problems connected with the Society's business and any proposed alterations in the existing Rules, or to frame new Rules, for the classification, survey and building of ships (hull and machinery).

3. The term of office of all Members to be four years, one-fourth retiring each year, the Members so retiring to be eligible for renomination for a second term. Unless specially so authorised by the General Committee, no Member, other than the Chairman and/or Vice-Chairmen, who has served for two periods

of four years to be eligible for renomination for a third term until after the expiration of at least one year. In the event of any vacancy occurring before the expiration of a term of four years a representative to be nominated to fill the vacancy for the unexpired portion of the term.

4. With the exception of any Superintendents nominated by the Technical Committee, only those who are actually partners in firms, or directors or managers of joint stock companies, or of similar status, to be eligible for membership.

5. The Technical Committee to appoint from their own body, biennially, a Chairman, who must be a Member of the General Committee, and, if desired, two Vice-Chairmen, who need not be Members of the General Committee. The same Members not to be eligible to hold office for more than four years in succession, unless on the occasion of the third election a ballot—to be taken whether there be any other candidates or not—shows a majority in their favour of at least three-fourths of the Members present. The appointment of Chairman and of Vice-Chairmen to be confirmed by the General Committee.

6. Meetings of the Technical Committee to be convened as often and at such times and places as may appear necessary, but there shall be at least three meetings in each year.

7. Members desiring to propose alterations in, or additions to, the Rules for the classification, survey or building of ships (hull and machinery) shall give notice of all such proposals in writing to the Secretary.

Every meeting to be convened by notice from the Secretary, if possible one month before the date of meeting; and the Secretary to send to each Member an agenda paper as soon as possible thereafter.

8. Any proposals of the Technical Committee involving any amendment of, or addition to, the Rules for the classification, survey or building of ships (hull and machinery) to be reported to the General Committee, who will refer them to a special meeting of the General Committee; as required by Section 11 of this Chapter.

9. The Technical Committee to be empowered:—

(i) to draw up, if they so desire, By-Laws for governing procedure at meetings;

(ii) to appoint Panels of the Committee;

(iii) to co-opt to the main Committee, or to such Panels, representatives of any organisation or industry or private individuals for the purpose of considering any particular problem.

10. The General Committee reserve to themselves the right of varying, adding to, or rescinding, at their discretion, any or all the foregoing Regulations in this Section.

## Section 14

All reports of survey are to be made by the Surveyors according to the form prescribed, and submitted for the consideration of the General Committee, or of the Sub-Committees of Classification but the character assigned by the latter to be subject to confirmation by the General Committee.

## Section 15

The reports of the Surveyors (and all documents and proceedings relating to the classification of ships) are to be carefully preserved and shall, subject to the approval, in his absolute discretion, of the Chairman, or one of the Deputy-Chairmen, be open to the inspection of the Owner and of any other person authorised in writing by the Owner.

Copies of reports will, subject to the approval of one of the Chairmen as indicated above, be supplied to Owners, or their representatives, on application.

## Section 16

The Surveyors to the Society are not to be permitted (without the especial sanction of the Committee) to receive any fee, gratuity, or reward whatsoever for their own use or benefit, for any service performed by them in their capacity of Surveyors to this Society, on pain of immediate dismissal.

## Section 17

While the Committees of the Society use their best endeavours to ensure that the functions of the Society are properly executed, it is to be understood that neither the Society nor any Member of any of its Committees is under any circumstances whatever to be held responsible for any inaccuracy in any report or certificate issued by the Society or its Surveyors, or in any entry in the Register Book or other publication of the Society, or for any error of judgment, default or negligence of any of its Committees or any Member thereof, or the Surveyors, or other Officers or Agents of the Society.

## Section 18

The funds and accounts to be under the authority and control of the Committee.

## Section 19

Fees are chargeable for all surveys held by the Society's Surveyors at ports in the United Kingdom in accordance with established scales.

For all surveys held at ports abroad fees will be chargeable according to the nature and extent of the services rendered.

Travelling expenses incurred by the Surveyors in connection with the above services are also chargeable.

## Section 20

The class of a ship is liable to be withheld, or, if already granted, may be withdrawn from the Register Book, in the case of non-payment of any fees or expenses chargeable on account of such ship.

*27th February, 1964*

# Chapter B

# CLASSIFICATION REGULATIONS

## Section 1

### CLASSIFICATION

**General**

**101** Steel ships built in accordance with the Society's Rules and Regulations, or with alternative arrangements equivalent thereto (*see* B 501), will be assigned a class in the Register Book and will continue to be classed so long as they are found, upon examination at the prescribed annual and other periodical surveys, to be maintained in a fit and efficient condition and in accordance with the requirements of the Rules.

The Committee, in addition to requiring compliance with the Society's Rules, may require to be satisfied that very small ships, or ships of special type are suitable for the geographical limits of service contemplated.

Classification will be conditional upon compliance with the Society's requirements in respect of both hull and machinery (i.e., main and auxiliary engines, boilers, essential appliances, pumping arrangements and electrical equipment).

The Rules are framed on the understanding that ships will be properly loaded and handled; they do not provide for special distributions or concentrations of loading. The Committee may also require additional strengthening to be fitted in any ship which, in their opinion, may be subjected to severe stresses due to particular features in her design or when it is desired to make provision for exceptional loaded or ballasted conditions. In these cases particulars are to be submitted for consideration.

The Committee cannot assume responsibility for stability, trim, hull vibration or other technical characteristics not covered by the Rules, but they are willing to advise on these matters. They are also willing to act in respect of national and international statutory safety and other requirements for passenger and cargo ships governing arrangements not covered by the Society's Rules.

**Character of Classification and Class Notations**

**102** Class 100A1. This class will be assigned to sea-going ships built in accordance with the Society's Rules and Regulations for the draught required.

**103** Class 100A1 oil tanker. This class will be assigned to sea-going tankers intended to carry oil in bulk and built in accordance with the Society's Rules and Regulations for the draught required.

Where the scantlings and arrangements have been approved by the Committee for the carriage of oil having a flash point above 65,5° C., or other liquid cargoes in bulk, the class notation affixed to the character will be suitably modified to show the nature of the cargo.

**104** Class 100A1 liquefied gas carrier, type of gas(es) in independent tanks, maximum vapour pressure, minimum temperature and where necessary maximum temperature (to be specified). This class will be assigned to sea-going ships specially designed for the carriage of liquefied petroleum, natural or other gases and built in accordance with the Society's Rules and Regulations for the draught required.

**105** Class 100A1 ore carrier. This class will be assigned to sea-going ships specially designed for the carriage of ore and built in accordance with the Society's Rules and Regulations for the draught required.

**106** Class 100A1 trawler, 100A1 stern trawler, 100A1 fishing vessel. These classes will be assigned to ships built in accordance with the appropriate Rules and Regulations for the Construction of Steel Trawlers.

**107** Class 100A1 tug. This class will be assigned to all sea-going tugs built in accordance with the Society's Rules and Regulations for such ships.

**108** Class 100A1 dredger, 100A1 hopper dredger, 100A1 hopper barge. These classes will be assigned to dredgers and hopper barges built in accordance with the Society's Rules and Regulations for such ships.

**109** Class 100A1 for restricted service or for special purposes. This class will be assigned to sea-going ships intended to operate within specific limits or for special purposes and built in accordance with the Society's Regulations and the scantlings, arrangements and equipment specially approved by the Committee for such ships. The class notation affixed to the character in the Register Book will indicate the geographical limits of the service or the particular purpose for which the class is assigned.

**110** Class A1 for restricted service. This class will be assigned to ships intended to trade only within specially sheltered waters, such as harbours, rivers or estuaries, provided the scantlings, arrangements and equipment are approved by the Committee as suitable for such service. The class notation affixed to the character will indicate the geographical limits for which the ship has been approved.

**111** Special cargoes. When the scantlings and arrangements have been approved for cargoes of a special nature an appropriate class notation will be entered in the Register Book.

**112** Special features. When a special feature in the design or construction of a ship or its machinery has been approved, an appropriate class notation may be entered in the Register Book.

**113** Corrosion control. Where an approved method of corrosion control is fitted and an appropriate reduction in scantlings has been permitted, the notation (cc) will be entered in the Register Book.

**114** Strengthening for Navigation in Ice. Where an ice class notation is desired, additional strengthening is to be fitted in accordance with the special requirements given in the Rules which are based on Baltic conditions. Three classes of ice strengthening are detailed in the Rules:—

Ice Class 1 strengthening is for ships intended to navigate in severe ice conditions.

Ice Class 2 strengthening is for ships intended to navigate in intermediate ice conditions.

Ice Class 3 strengthening is for ships intended to navigate in light ice conditions.

It is the responsibility of the owner to determine which notation is most suitable for his requirements.

## Section 2

### EQUIPMENT

**201** The figure 1 in the character of classification assigned to a ship indicates that her equipment of anchors, chain cables and hawsers is in good and efficient condition and in the cases of ships not classed for a special or restricted service, in accordance with the requirements of the Rules. In the case of ships classed for a special or restricted service, the figure 1 indicates that the equipment has been approved by the Committee as suitable for the particular service.

**202** When the equipment of a ship is not supplied or maintained in accordance with the requirements of the Rules but is considered by the Committee to be acceptable for the particular service, the Committee may agree to the figure 1 being omitted and a line inserted after the character, thus, 100A–. In cases where the equipment is found to be seriously deficient in quality or quantity, the class of the ship will be liable to be withheld from the Register Book. Special consideration will be given to ships intended to be classed for which, by reason of their particular purpose or service, normal equipment may be unnecessary. In such cases the figure 1 may be omitted from the character of classification, viz., 100A.

## Section 3

### MACHINERY

**301** The machinery, as defined in B 101, is to be constructed and installed on board ship in accordance with the Society's Rules and Regulations. On satisfactory completion of trials, an appropriate class notation will be assigned in the Register Book, thus, LMC (Lloyd's Machinery Certificate).

## Section 4

### MATERIALS

**401** The materials used in the construction of hulls and machinery intended for classification, or in the repair of ships already classed, are to be of good quality and free from defects and are to be tested under the supervision of the Society's Surveyors in accordance with the requirements of Chapter P. The steel is to be manufactured by an approved process at works recognised by the Committee. Alternatively, tests to the satisfaction of the Committee will be required to demonstrate the suitability of the steel.

## Section 5

### EQUIVALENT ARRANGEMENTS

**501** Alternative arrangements will be permitted, provided they are considered by the Committee to be equivalent to the Society's requirements. The Owners' consent shall be obtained to such alternatives when the Committee deem this necessary.

## Section 6

### NEW CONSTRUCTION

**Submission of Plans**

**601** When it is intended to build a ship for classification with the Society, constructional plans and particulars of the hull, equipment and machinery (*see* B 101), as detailed in the Rules, are to be submitted through the local Surveyors for the approval of the Committee before the work is commenced.

Any subsequent modifications or additions to the scantlings, arrangements or equipment shown on the approved plans are also to be submitted for approval.

**Novel Forms of Construction**

**602** Where the proposed construction of any part of the hull or machinery is novel in design, or involves the use of unusual material, or where experience, in the opinion of the Committee, has not sufficiently justified the principle or mode of application involved, special tests or examinations before and during service may be required. A suitable notation will be inserted in the Register Book when the Committee consider this necessary.

**Special Survey during Construction**

**603** New ships intended for classification are to be built under the Society's Special Survey and when classed will be entitled to the distinguishing mark ✠ inserted before the character in the Register Book thus: ✠100A1.

New machinery for ships classed or intended for classification is to be constructed under the Society's Special Survey, and on completion will be entitled to the distinguishing mark ✠ inserted before the machinery class notation in the Register Book, thus: ✠LMC.

From the commencement of the work until the completion of the ship and final test of the machinery under working conditions, the Surveyors are to examine the materials, workmanship and arrangements. Any items not in accordance with the Rules or the approved plans, or any material, workmanship or arrangement found to be unsatisfactory are to be rectified.

**Date of Build**

**604** The date of completion of the Special Survey during Construction of ships built under the Society's inspection will normally be taken as the date of build to be entered in the Register Book. If the period between launching and completion or commissioning is, for any reason, unduly prolonged, the dates of launching and completion or commissioning may be separately indicated in the Register Book.

When a ship upon completion is not immediately put into commission, but is laid up for a period, the Committee, upon application by the Owner, prior to the ship proceeding to sea, may direct an examination of the ship to be made in dry dock by the Society's Surveyors. If, as the result of such survey, the hull and machinery be reported in all respects free from deterioration, the subsequent Special Survey will date from the time of such examination.

## Section 7

### CLASSIFICATION OF SHIPS NOT BUILT UNDER SURVEY

**701** The requirements of the Committee for the classification of ships which have not been built under the Society's survey are set forth in C 12.

## Section 8

### PERIODICAL SURVEYS

**Annual Surveys**

**801** All steel ships should be surveyed at intervals of approximately one year, in accordance with the requirements set forth in C 1.

**Docking Surveys**

**802** Owners or their representatives should notify the Society or its Surveyors whenever a ship can be examined in dry dock or on a slipway. It is desirable that ships should be examined in dry dock at intervals of about 12 months; the maximum interval is to be two years.

The date of the last examination in dry dock or on a slipway will be recorded in the Supplement to the Register Book.

**Special Surveys**

**803** All steel ships classed with the Society are also to be subjected to Special Surveys in accordance with the requirements set forth in C 2 to C 8. These surveys become due at 4-yearly intervals, the first 4 years from the date of build or date of Special Survey for Classification, and thereafter 4 years from the date of the previous Special Survey.

**Period allowed for completion of Special Surveys**

**804** When it is inconvenient for Owners to fulfil all the requirements of a Special Survey at its due date, the Committee will be prepared to consider its postponement, either wholly or in part, provided that the Society's Surveyors are afforded an opportunity, about the due date, of assessing the general condition of hull and machinery. For this purpose the Committee will normally call for a general examination of the ship, including drydocking, of sufficient extent to be assured that her condition is satisfactory for the period of grace desired, which is not to exceed 12 months from the due date.

Special Surveys which are commenced prior to their due date are not to extend over a period greater than 12 months, except with the prior approval of the Committee, who will be prepared to consider suitable arrangements for carrying out Special Surveys over an extended period in the case of ships engaged on a regular schedule.

**Record of Special Surveys**

**805** Ships which have satisfactorily passed a Special Survey will have a record entered in the Supplement to the Register Book indicating the date. For Special Surveys at which the prescribed requirements as to drilling of the shell and strength deck plating have been complied with, the record Dr will

be entered. Where a Special Survey is not completely carried out at one time, the date recorded in the Supplement will be the date at which the principal part of the requirements is complied with. Records of Special Survey will not be assigned until the Society's requirements for machinery surveys detailed in 807 or 808 are satisfactorily completed.

**Continuous Surveys**

**806** When, at the request of the Owners, it has been agreed by the Committee that the complete survey of the hull may be carried out on the Continuous Survey basis, all compartments of the hull should be opened for survey and testing in rotation to ensure that the interval between consecutive examinations of each part will not exceed the period normally allowed by the Regulations between Special Surveys.

If the examination during Continuous Survey reveals any defects, further parts are to be opened up and examined as considered necessary by the Surveyor.

Ships which have satisfactorily completed the cycle will have a record entered in the Supplement to the Register Book indicating the date.

**Surveys of Machinery**

**807** Machinery, as defined in B 101, is to be submitted to the surveys set forth in C 5 to C 11.

Complete Surveys are to be carried out as part of the Special Survey and, whether or not they are commenced prior to their due date, are not to extend over a period greater than 12 months without approval. On satisfactory completion of the survey an appropriate record will be made in the Supplement to the Register Book. When a Complete Survey of the machinery is not carried out at one time the date recorded in the Supplement will be that on which the major portion of the survey is carried out.

If it is found desirable that any part of the machinery should be again examined before the due date of the next survey, a certificate for a limited period will be granted in accordance with the nature of the case.

**Continuous Surveys of Machinery**

**808** When, at the request of Owners, it has been agreed by the Committee that the Complete Survey of the machinery may be carried out on the continuous survey basis, the various items of machinery should, so far as practicable, be opened for survey in rotation to ensure that the interval between consecutive examinations of each item will not exceed the four-yearly period normally allowed by the Regulations between Special Surveys, and that approximately one quarter of the machinery is examined each year.

In such cases a record indicating the date of completion of the cycle will be made in the Supplement to the Register Book.

Where it is inconvenient for Owners to carry out a Special Survey of a ship at its due date, and proposals for its postponement, either wholly or in part, have been submitted to and approved by the Committee, the Continuous Survey of the machinery should still proceed as described above during the period of postponement of the Special Survey.

If the examination during Continuous Survey reveals any defects, further parts are to be opened up and examined as considered necessary by the Surveyor and the defects made good to his satisfaction.

**Boiler, Steam Pipes and Screw Shaft Surveys**

**809** Boiler Surveys, examination of Steam Pipes and Screw Shaft Surveys should be carried out as set forth in C 9, C 10 and C 11. On satisfactory completion, appropriate records will be made in the Supplement to the Register Book.

## Section 9

### REFRIGERATION

**901** On application from Owners, refrigerated cargo installations which comply with Chapter N of the Rules and are favourably reported on by the Surveyors will be assigned an appropriate class in accordance with N 1. Certificates will be issued and the class notation, together with the particulars of the installation, will be entered in the Supplement.

**902** The class assigned will be retained provided the installation is found to be in a good and efficient condition at the Periodical, Loading Port and other Surveys set forth in N 8.

## Section 10

### REPAIRS AND ALTERATIONS

**Repairs**

**1001** All repairs to hull, equipment and machinery which may be required in order that a ship may retain her class are to be carried out under the inspection of, and to the satisfaction of, the Society's Surveyors. When repairs are effected at a port where there is no Surveyor to this Society, the ship is to be surveyed by one of the Society's Surveyors at the earliest opportunity.

**1002** When at any survey the Surveyors consider repairs to be necessary, either as a result of damage, or of wear and tear, they will communicate their recommendations at once to the Owners, or their representative, and if compliance therewith cannot be arranged, immediate notification will be given by the Surveyors to the Committee.

**Alterations**

**1003** Plans and particulars of any proposed alterations to the approved scantlings and arrangements of hull, equipment, or machinery are to be submitted for approval and such alterations are to be carried out under the inspection of, and to the satisfaction of, the Society's Surveyors.

## Section 11

### APPEAL FROM SURVEYORS' RECOMMENDATIONS

**1101** If the recommendations of the Society's Surveyors are considered in any case to be unnecessary or unreasonable, appeal may be made to the Committee, who may direct a special examination to be held.

## Section 12

### NOTICE OF SURVEYS

**1201** It is the responsibility of Owners to ensure that all surveys necessary for the maintenance of class are carried out at the proper time under the supervision of the Society's Surveyors.

It is, however, the normal practice of the Society to give timely notice to Owners when Special Surveys become due, but the non-receipt of such notice, or of notice regarding other surveys, does not absolve Owners from this responsibility.

## Section 13

### CERTIFICATES

**1301** When the required reports on completion of the Special Surveys of new ships, or of existing ships submitted for classification, have been received from the Surveyors and approved by the Committee, certificates of first entry of classification, signed by the Chairman, Deputy-Chairman and Treasurer, or Deputy-Chairman and Chairman of the Sub-Committees of Classification, and countersigned by the Secretary, will be issued to Builders or Owners.

**1302** Certificates of class maintenance in respect of completed periodical surveys of hull and machinery will also be issued to Owners on application.

**1303** The Society's Surveyors are permitted to issue provisional certificates to enable a ship, classed with the Society, to proceed on her voyage provided that, in their opinion, she is in a fit and efficient condition. Such certificates will embody the Surveyor's recommendations for continuance of class, but in all cases are subject to confirmation by the Committee.

## Section 14

## WITHDRAWAL OF CLASS

### Owners' Request

**1401** When the class of a ship, for which the Regulations as regards surveys on hull, equipment and machinery have been complied with, is withdrawn by the Committee in consequence of a request from the Owners, the notation "Class withdrawn at Owners' request" (with date) will be made in the Supplement and the notation "LR class withdrawn—Owners' request" (with date) will be made in the next reprint of the Register Book. After one year the notation will be altered to "Classed LR until" (with date).

### Non-Compliance with the Regulations

**1402** When the Regulations as regards surveys on the hull or equipment or machinery have not been complied with and the ship thereby is not entitled to retain her class, the class will be withdrawn and the notation "Class withdrawn" (with date) will be made in the Supplement and the notation "LR class withdrawn" (with date) will be made in the next reprint of the Register Book. After one year the notation will be altered to "Classed LR until" (with date).

### Reported Defects

**1403** When it is found from reported defects in the hull or equipment or machinery that a ship is not entitled to retain her class in the Register Book, and the Owners fail to repair such defects in accordance with the Society's requirements, the class will be withdrawn and the notation "Class withdrawn—Reported defects" (with date) will be made in the Supplement and the notation "LR class withdrawn—Reported defects" (with date) will be made in the next reprint of the Register Book. After one year the notation will be altered to "Classed LR until" (with date).

### Infringement of Freeboard Conditions

**1404** Where any ship proceeds to sea with a less freeboard than that approved by the Committee or where the freeboard marks are placed higher on the ship's sides than the position assigned or approved by the Committee, the ship's class will be liable to be withdrawn.

## Section 15

## RECLASSIFICATION OF SHIPS

**1501** When reclassification is desired for a ship for which the class previously assigned has been withdrawn, the Committee will direct a Special Survey for Reclassification, appropriate to the age of the ship and the circumstances of the case, to be carried out by the Society's Surveyors.

If at such survey the ship be found or placed in a good and efficient condition in accordance with the requirements of the Rules and Regulations the Committee will be prepared to reinstate her original class or assign such other class as may be deemed necessary.

The date of reclassification will be recorded in the Supplement to the Register Book.

*30th July, 1964*

# Chapter C

# PERIODICAL SURVEY REGULATIONS

## Section 1

### ANNUAL AND DOCKING SURVEYS

#### Annual Surveys

**101** Annual Surveys as required by B 801 should, whenever practicable, be held concurrently with statutory annual or other load line surveys.

**102** The Surveyor is to satisfy himself as to the efficient condition of the following:—

Hatchways and their closing and securing appliances on freeboard and superstructure decks.

Exposed casings, superstructure bulkheads, companionways, ventilator coamings, air pipes, fiddley openings, flush bunker scuttles, sidelights and skylights with their closing appliances, which protect openings in freeboard or superstructure decks.

Gangways, cargo and coaling doors, ash shoots and other openings in the ship's sides, with their securing appliances; also freeing port shutters in bulwarks. Scuppers are to be examined so far as practicable.

The Surveyor should satisfy himself regarding the freeboard marks on the ship's side.

**103** Attention is to be paid to all parts of rod and chain gears. All pins are to be examined and the chain in the vicinity of the blocks is to be cleaned and examined for wear and tear. Any length of chain so worn that its mean diameter at its most worn part is reduced to the size given in Chapter D, Table 55, is to be renewed.

All replacements of chains are to be subjected, under the Society's supervision, to the proof tests as set forth for short-link cables in P 13 and the certificates are to be produced. It is recommended that, in addition, the breaking test as required in P 13 should be applied to these chains, and that the tests be made at a proving establishment recognised by the Committee.

It is recommended that repaired chains be tested by the repairers and a certificate to that effect produced.

It is recommended that a set of spares as required by D 2714 be provided.

**104** The various parts of the auxiliary steering gear are to be assembled and examined in order to ascertain that the gear is in good and workable condition.

#### Docking Surveys

(*See* B 802)

**105** When a ship is in dry dock or on a slipway she is to be placed on blocks of sufficient height, and proper staging is to be erected as may be necessary for the examination of the shell plating, sternframe and rudder.

Attention is to be given to parts of the structure particularly liable to excessive corrosion or to deterioration from causes such as chafing and lying on the ground and to any undue unfairness of the plating of the bottom.

General

**106** At Annual and Docking Surveys the Surveyor should examine the ship so far as is practicable in order to satisfy himself generally as to her condition.

**107** When chain cables are ranged the anchors and cables should be examined by the Surveyor.

**108** The requirements for the survey of main and auxiliary engines, boilers and electrical equipment are set forth in C 5 to C 11.

Annual and Biennial Surveys of Fire Equipment

**109** The arrangements for fire protection, detection and extinction in passenger ships are to be examined annually; in cargo ships the arrangements for fire detection and extinction are to be examined biennially.

Surveys carried out by the National Authorities of the countries in which ships are registered may be accepted as meeting these requirements.

Surveys for Damage or Alterations

**110** At any time when a ship is undergoing damage repairs or alterations, any exposed parts of the structure normally difficult of access should be specially examined, e.g., if any part of the main or auxiliary machinery, including boilers, or insulation or fittings is removed for any reason the steel structure in way should be carefully examined by the Surveyor, or when cement in the bottom or covering on decks is removed the plating in way should be examined before the cement or covering is relaid.

## Section 2

## SPECIAL SURVEYS—HULL REQUIREMENTS

(*For Tankers, see also* C 3.)

**(A) At the Special Survey of ships under 5 years old.**

**201** The ship is to be placed on blocks of sufficient height in a dry dock, or on a slipway; proper staging is to be erected as necessary and the shell plating, sternframe and rudder are to be examined.

The rudder is to be lifted for examination of pintles if deemed necessary by the Surveyor.

**202** The holds, peaks, deep tanks, engine and boiler spaces, coal bunkers and other spaces are to be cleared and cleaned as necessary and examined. The bilges and limbers all fore and aft are to be cleaned and the structure examined. Platform plates in engine and boiler spaces are to be lifted as may be necessary for the examination of the structure below.

Where necessary close and spar ceiling, lining and pipe casings are to be removed for examination of the structure.

**203** In ships having a single bottom, a sufficient amount of close ceiling is to be lifted all fore and aft on each side from the bottom and bilges to permit the structure below to be examined. Where the ceiling is fitted in hatches, these are to be lifted.

**204** In ships having a double bottom, a sufficient amount of ceiling is to be removed from the bilges and inner bottom to enable the condition of the plating to be ascertained. If it is found that the plating is clean and in good condition, and free from rust, the removal of the remainder of ceiling may be dispensed with. The Surveyor may waive the removal of heavy reinforced compositions if there is no evidence of leakages, cracking or other faults in the composition.

**205** The steelwork is to be exposed and cleaned as may be required for its proper examination by the Surveyor. Careful examination is to be made of parts of the structure particularly liable to excessive corrosion or to deterioration from causes such as chafing, lying on the ground, or handling of cargo.

Attention is to be given to the examination of gangway, cargo or coaling doors, ash shoots and to the shell plating in way of these and other openings.

The Surveyor may require to ascertain by drilling or other approved means, the thickness of the material in any portion of the structure where signs of wastage are evident or wastage is normally found. Any parts of the structure which are found defective or materially reduced in scantlings are to be made good by materials of the approved scantlings and quality. Attention is to be given to the structure in way of discontinuities. Surfaces are to be recoated as necessary.

**206** In cases where the inner surface of the bottom plating is covered with cement, asphalt, or other composition, the removal of this covering may be dispensed with, provided it be carefully inspected, tested by beating or chipping, and found sound and adhering satisfactorily to the steel.

**207** Double bottom compartments, peak tanks and all other tanks are to be tested by a head sufficient to give the maximum pressure that can be experienced in service.

Tanks may be tested afloat provided their internal examination is also carried out afloat.

Tanks forming parts of the main structure, except as stated below, are to be cleaned and examined internally, special attention being given to tanks under boiler spaces. Tanks (excluding peak tanks) used exclusively for oil fuel or for oil fuel and fresh water need not be examined internally provided, after external examination and testing in accordance with the requirements set out above, the Surveyor finds the condition of these compartments satisfactory.

**208** All decks, machinery and other casings, superstructures, skylights, companionways, ventilators, and air pipes together with all opening and closing appliances, are to be examined. Attention should be given to the examination of strength decks and topsides in way of the corners of openings and at other discontinuities.

**209** Wood decks or sheathing are to be examined ; if decay or rot is found or the wood is excessively worn it should be renewed. When a wood deck, laid on stringers and ties, originally required to be 75 mm. is worn to 65 mm., or 65 mm. to 50 mm., it is to be renewed.

Attention is to be given to the condition of the plating under wood decks, sheathing or other deck covering. If it is found that such coverings are broken or are not adhering closely to the plating, sections should be removed as necessary to ascertain the condition of the plating. (*See also* C 110.)

**210** The hatchway coamings are to be examined. Covers, hatch beams and supports throughout, tarpaulins, cleats, battens and other means of securing the hatchways, are to be examined separately and in position. Attention should be paid to the means of ensuring watertightness of steel hatch covers.

**211** The masts, rigging, anchors and general equipment are to be examined. If the chain cables are ranged they should be examined. (*See* Chapter D, Table 55, for renewals.)

**212** The steering gear, and its connections and control gear are to be examined and all parts of rod and chain gears are to be dismantled, cleaned and examined. (*See also* C 502, Steering Machinery.) Any length of chain so worn that its mean diameter at its most worn part is reduced to the size given in Chapter D, Table 55, is to be renewed.

All replacements of chains are to be subjected, under the Society's supervision, to the proof tests as given for short link cables in P 13, and the certificates are to be produced. It is recommended that, in addition, the breaking test as required in P 13 should be applied to these chains, and that the tests be made at a proving establishment recognised by the Committee.

It is recommended that repaired chains be tested by the repairers and a certificate to that effect produced.

It is recommended that a set of spares as required by D 2714 be provided.

The various parts of the auxiliary steering gear are to be assembled and examined to ascertain that the gear is in good and workable condition.

**213** The windlass (*see* C 502), pumps, suctions, watertight doors, sidescuttles and deadlights, freeing port shutters, overboard scuppers and discharge pipes, and air and sounding pipes are to be carefully examined.

When examining tanks internally the Surveyor is to see that striking plates are fitted under sounding pipes.

**214** Where holds are insulated for the purpose of carrying refrigerated cargoes, and the hull in way of the insulation was examined by the Society's Surveyors at the time such insulation was fitted, it will be sufficient to remove the limbers and hatches to enable the framing and plating in way to be examined; in other cases additional insulation is to be removed as necessary to satisfy the Surveyor as to the condition of the structure. (*See also* N 8.)

**215** The freeboard recorded in the Appendix to the Register Book is to be verified.

**216** The main and auxiliary engines and boilers and electrical equipment are to be examined in accordance with the requirements of C 5 to C 11 and favourably reported on by the Society's Engineer Surveyors.

**(B) At each Special Survey of ships between 5 and 10 years old.**—THE FULL REQUIREMENTS OF 201 TO 216 ARE TO BE COMPLIED WITH, TOGETHER WITH THE FOLLOWING :—

**217** A sufficient amount of ceiling in the holds and in coal bunkers is to be removed from the bilges and inner bottom to enable the condition of structure in the bilges, the inner bottom plating, pillar feet, and the bottom plating of bulkheads and tunnel sides to be examined. If the Surveyor deems it necessary, the whole of the ceiling is to be removed.

**218** In ships having a single bottom the limber boards and ceiling equal to not less than three strakes all fore and aft on each side are to be removed, one such strake being taken from the bilges. Where the ceiling is fitted in hatches, the whole of the hatches and at least one strake of ceiling in the bilges are to be removed. If the Surveyor deems it necessary the whole of the ceiling and limber boards are to be removed.

**219** Tanks (excluding peak tanks) used exclusively for oil fuel or for oil fuel and fresh water need not all be examined internally provided, from an external examination and testing and from an internal examination of the after end of one forward double bottom tank, and of one selected deep tank, the Surveyor is satisfied with the condition.

Lubricating oil tanks need not be examined internally.

**220** The chain cables are to be ranged for inspection, and the anchors and chains examined. If any length of chain cable is found to be reduced in mean diameter at its most worn part to the extent indicated in Chapter D, Table 55, it is to be renewed.

**221** The chain locker is to be cleaned and examined internally.

**(C) At each Special Survey of ships over 10 years old.**—THE FULL REQUIREMENTS OF 201 TO 221 ARE TO BE COMPLIED WITH, TOGETHER WITH THE FOLLOWING :—

**222** The steel work is to be cleaned and the rust removed.

**223** Casings of air, sounding, steam and other pipes, spar ceiling and lining in way of the sidescuttles are to be removed as required by the Surveyor.

**224** If the Surveyor is satisfied after removal of portions of the ceiling in the holds, that the steel work is in good condition, free from rust, and coated, the removal of the whole may be dispensed with. In coal bunkers, however, the whole of the ceiling is to be removed.

**225** Attention is to be given by the Surveyor to the inside of coal bunkers and the parts in way of the boilers.

**226** Attention is also to be paid to the possibility of local wastage and grooving, e.g., at the shell plating along the heel of framing members.

**227** All double bottom and other tanks are to be cleaned as necessary to permit their being examined internally, where this is required.

For ships of 10 and not more than 15 years old, tanks (exclusive of peaks) used exclusively for oil fuel, oil fuel and fresh water, or lubricating oil need not all be examined internally provided, from an external examination and testing and from an internal examination of one double bottom tank forward and one aft and one deep tank, the Surveyor is satisfied with the condition.

For ships of 15 and not more than 20 years old, at least one oil fuel double bottom tank amidships, one forward and one aft and one deep tank should be examined internally. These tanks should be selected so that as many different tanks as possible are examined internally before the ship is 20 years old. For ships 20 years old and over, all tanks should be examined internally.

**228** The cement chocks on the ship's sides at bilges and decks are to be examined, and portions removed, so that the condition of the shell plating and adjacent steel work can be ascertained. Portions of wood sheathing, or other covering, on steel decks are to be removed as considered necessary by the Surveyor in order to ascertain the condition of the plating.

**229** Where the holds are insulated for the purpose of carrying refrigerated cargoes, the limbers and hatches are to be lifted, and sufficient insulation is to be removed in each of the chambers to enable the Surveyor to satisfy himself of the condition of the framing and plating. (*See also* N 8.)

**230** All mast wedging is to be removed and renewed as necessary.

**(D) At the first Special Survey held after the ship is 24* years old and at every 12* years thereafter or at the next Special Survey after the expiration of the latter period**—THE FULL REQUIREMENTS OF 201 TO 230 ARE TO BE COMPLIED WITH, TOGETHER WITH THE FOLLOWING :—

**231** In addition to the drilling required by 205 to ascertain local wastage the shell plating and plating of strength decks are to be gauged by drilling or other approved means to determine the amount of any general diminution in thickness. The gauging is to be done in at least two places in each strake of plating on each side within the amidships half length, preferably clear of coal bunkers and deep tanks.

All paint and rust is to be entirely removed before the plates are gauged by the Surveyor and the actual thicknesses are to be reported in detail to the Committee. Where drilled plates are renewed the thickness of adjacent plates in the same strake should be reported.

The thickness of bottom plating in way of cement is to be ascertained unless the Surveyor, after an internal and external examination, is entirely satisfied that this is unnecessary. Selected portions of the cement are to be removed from the bottom and bilge if required by the Surveyor.

**232** Where the holds are insulated for the purpose of carrying refrigerated cargoes, the limbers and hatches are to be lifted, and sufficient additional insulation is to be removed in each of the chambers to enable the Surveyor to satisfy himself of the condition of the steel structure, and to enable the thickness of the shell plating to be ascertained as required by 231.

* *For tankers see* C 307.

## Section 3

## SPECIAL SURVEYS—TANKERS

HULL REQUIREMENTS ADDITIONAL TO THOSE STATED IN C 2

### Preparation and Inspection of Tanks

**301** At all Special Surveys all cargo tanks and cofferdams are to be cleaned out, thoroughly cleared of gas, and examined. Every precaution is to be taken to ensure safety during inspection.

Attention is to be given to the inside of the bottom plating in order to ensure that there is no excessive pitting of the plating. When extensive pitting is found care should be taken to preserve the longitudinal strength of the bottom by the requisite renewals or repairs. In cases where cement has been laid in the bottom the Surveyor is to satisfy himself that there is no active corrosion under the cement.

**302** The strums of the cargo suction pipes are to be removed to facilitate examination of the shell plating and bulkheads in that vicinity, unless other means for visual inspection of these parts are provided.

**303** The attachment to the structure and condition of anodes in tanks is to be examined.

### Testing

**304** Each cargo tank bulkhead is to be tested at Special Surveys A and B by filling alternate tanks with water to the top of the hatchway. But at subsequent Special Surveys, or earlier if considered necessary by the Surveyor, all tanks are to be tested.

**305** Tanks may be tested when the ship is afloat, provided the internal examination of the bottom is also carried out afloat.

**306** Where extensive repairs have been effected to the shell plating, the tanks should be tested to the Surveyor's satisfaction.

### Drilling

**307** The thickness of shell and deck plating in way of tanks is to be ascertained by drilling or other approved means at the first Special Survey after the ship is 12 years old and at intevals of 4 or 8 years thereafter or at the next Special Survey after the expiry of these periods. The interval between the determination of the thickness will be regulated by the condition of the structure revealed at the survey and the repairs effected.

## Section 4

## LIQUEFIED GAS CARRIERS

ANNUAL AND SPECIAL SURVEYS—REQUIREMENTS ADDITIONAL TO THOSE STATED IN C 1, C 2 AND C 3

### Preparation before Survey

**401** Prior to inspection of cargo tanks, cofferdams, associated piping, fittings or equipment, the respective items are to be cleaned and thoroughly cleared of gas. Every precaution is to be taken to ensure safety during inspection.

### Annual Surveys

**402** Where the maximum vapour pressure for which the cargo tanks have been approved as recorded in the Register Book is 0,7 kg. per cm.$^2$, or less, the inner surfaces of the tanks are to be examined annually.

### Special Surveys

**403** At each Special Survey of the ship the tanks are to be examined internally, also externally as far as practicable, particular attention being paid to the plating in way of supports and securing arrangements, mountings and pipe connections, also to sealing arrangements at the deck.

Where the tanks are insulated, portions of the insulation are to be removed if required by the Surveyor to enable him to ascertain the condition of the plating.

Internal fittings are to be examined, all valves and cocks in direct communication with the interiors of the tanks are to be opened out for inspection and any pipes connecting them to the tanks are to be examined internally so far as practicable.

Liquid level indicating devices, high level alarms, monitoring systems for revealing possible gas leakage and arrangements for inerting the tanks and containment spaces are to be examined and tested to ascertain that they are in good working order.

Where provision is made for recording the temperature of the ship's structure adjacent to the tanks, the correct functioning of the apparatus, including audible alarms, is to be verified.

Pressure relief valves are to be opened out for inspection and subsequently adjusted to lift at a pressure not more than three per cent above the maximum vapour pressure for which the tanks have been approved. The valves may be removed from the tanks for the purpose of making this adjustment which may be effected under pressure of air or other suitable medium.

Vacuum relief valves are to be opened out, examined and tested to establish that they are in good working order.

Where the approved maximum vapour pressure of the cargo tanks is 0,7 kg. per cm.$^2$, or less, the tanks are to be tested by a head of water 2,45 metres above the top of the tank or 610 mm. above the top of the hatch, whichever is the greater. Where access to the outside of the cargo tanks is not possible other proposals for leak testing of the cargo tanks will be considered.

Where the approved maximum vapour pressure is above 0,7 kg. per cm.$^2$, the tanks are to be tested by pressure of water equal to one and a quarter times the approved maximum vapour pressure. Where these tanks are insulated, at the second Special Survey and at each alternate Special Survey thereafter, the insulation is to be removed in way of all supports and connections to the tanks and at the tank seams prior to the water pressure test.

Where insulation is attached to the hull structure, special consideration will be given to the necessity of removing it at Special Surveys but, in general, provided the Surveyor is satisfied that it is adhering properly and there are no traces of cold spots, this will not be required until the ship is at least eight years old. An examination of the wing tanks, double bottom tanks and transverse cofferdams, when the cargo tanks are loaded with liquefied gas at the minimum approved temperature, will be required at the Special Survey or at a convenient date immediately prior thereto.

**404** Where submerged electrically driven pumps are fitted in the cargo tanks, at each Annual and each Special Survey the pumps and motors are to be withdrawn from the tanks and opened out for examination of the condition of the stator winding insulation, evidence of any damage due to thermal expansion and contraction and bearing wear. Any sludge deposits in the motor windings or casings are to be removed and insulation resistances, including those of the motors and supply cables, are to be measured before opening out and after refitting. The portions of supply cables within the cargo tanks and the cable glands are to be examined for signs of deterioration and/or gas leakage.

The control devices and interlocks actuated by pressure or liquid level in the tanks and master key switches, which cut off the supply of current to the motors, are to be checked under simulated working conditions and if necessary re-calibrated.

Where deep well pumps are fitted in the cargo tanks, at each Special Survey the control devices which cut off the supply of current to the motors are to be checked under simulated working conditions and if necessary re-calibrated.

**405** Where refrigeration equipment is installed, either for maintaining the liquid cargo at the carrying temperature or for re-liquefying the "boil-off" and returning it to the tanks, a Special Survey of the equipment is to be carried out in accordance with the requirements of Chapter N for First and Subsequent Special Surveys, so far as applicable.

Section 5

## GENERAL REQUIREMENTS—MACHINERY

APPLICABLE TO ALL SHIPS

**At each Survey held in dry dock**

**501** When the ship is in dry dock the propeller, sternbush and sea connection fastenings are to be examined. The wear down of the sternbush or the efficiency of the oil gland should be ascertained.

**Special Surveys—Machinery Requirements**

**502** At each Complete Survey required by B 807 the following parts are to be opened up and examined:—

SEA CONNECTIONS

While the ship is in dry dock all openings to the sea in the machinery spaces and pump rooms with the valves, cocks and the fastenings with which these are connected to the hull.

SHAFTING

All shafts (except screw and tube shafts for which special arrangements are detailed in C 11), thrust block and all bearings. The lower halves of bearings need not be exposed if alignment and wear are found acceptable.

REDUCTION GEARS, complete with all wheels, pinions, shafts, bearings and gear teeth.

AUXILIARY ENGINES, auxiliary air compressors with their intercoolers, filters and/or oil separators and safety devices, and all pumps and components used for essential services.

STEERING MACHINERY.

WINDLASS.

EVAPORATORS and their safety valves, which should be seen in operation under steam.

SECURING ARRANGEMENTS

The holding down bolts and chocks of main and auxiliary engines, gear cases, thrust blocks and tunnel bearings.

AIR RECEIVERS

All air receivers for essential services with their mountings, valves and safety devices are to be cleaned internally and examined internally and externally. If internal examination of the air receivers is not practicable, they are to be tested hydraulically to twice the working pressure.

PUMPING ARRANGEMENTS

The valves, cocks and strainers of the bilge system including bilge injection, are to be opened up as considered necessary by the Surveyor and, together with pipes, are to be examined and tested under working conditions. The oil fuel, feed and lubricating oil systems and the ballast connections and blanking arrangements to deep tanks which may carry liquid or dry cargoes, together with all pressure filters, heaters and coolers used for essential services, are to be opened up and examined or tested as considered necessary by the Surveyor. All safety devices for the foregoing items are to be examined.

FUEL TANKS AND FITTINGS

Fuel tanks which do not form part of the ship's structure are to be examined and if considered necessary by the Surveyor they are to be tested to the pressure specified for new tanks. The tanks need not be examined internally at the first survey if they are found satisfactory on external inspection. All mountings, fittings and deck controls are to be examined as far as practicable.

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In addition to the above, detailed requirements for steam and internal combustion engines, electrical installations and boilers are given in C 6, C 7, C 8 and C 9 respectively.

## Section 6

### STEAM ENGINES—DETAILED REQUIREMENTS

**Complete Surveys**

**601** In addition to the requirements of C 5 the working parts of the main engines and attached pumps and of auxiliary machinery used for essential services including bulkhead stop valves, manœuvring valves, cylinders, pistons, valves and valve gear, piston rods, connecting rods, crossheads and guides, the crank shafts of reciprocating engines and the blading, rotors and casings of turbine machinery are to be opened up and examined.

Condensers, steam reheaters, desuperheaters which are not incorporated in the boilers and any other appliances used for essential services are to be examined to the satisfaction of the Surveyor, and if considered necessary they are to be tested.

The manœuvring of the engines is to be tested under working conditions.

**602** Exhaust steam turbines supplying power for main propulsion purposes in conjunction with reciprocating engines are, together with their gearing and appliances, steam compressors or electrical machinery, to be examined as far as practicable. Where cone connections to internal gear shafts are fitted, the coned ends are to be examined as far as practicable.

**603** In steam ships having essential auxiliary machinery driven by internal combustion engines, the prime movers of these auxiliaries are to be examined as detailed in C 701.

## Section 7

### INTERNAL COMBUSTION ENGINES—DETAILED REQUIREMENTS

**Complete Surveys**

**701** In addition to the requirements of C 5 the Complete Survey is to consist of the opening out and examination of the following parts: cylinders, covers, valves and valve gear, fuel pumps and fittings, scavenge pumps, scavenge blowers and their prime movers, superchargers, compressors, their intercoolers, filters and/or oil separators and safety devices, pistons, piston rods, crossheads, guides, connecting rods, crank shafts and all bearings, clutches, reverse gears, attached pumps, cooling system, crankcase door fastenings and explosion relief devices. Selected pipes in the starting air system are to be removed for internal examination and hammer-tested. If an appreciable amount of lubricating oil is found in the pipes, the starting air system is to be thoroughly cleaned internally by steaming or other suitable means. Some of the pipes selected are to be those adjacent to the starting air valves at the cylinders and to the discharges from the air compressors. The electric ignition system, if fitted, is to be examined and tested. The manœuvring of engines is to be tested under working conditions.

Where steam is used for essential purposes, the condensing plant, feed pumps, and oil fuel burning plant, are to be examined and the steam pipes examined and tested as detailed in C 10.

**702** Gas turbines and free piston gas generators: in addition to the requirements of C 5, the Complete Survey is to consist of the opening and examination of the following parts: the blading, rotors and casings of the turbines, the impellers or blading, rotors and casings of the air compressors, the combustion chambers, burners, intercoolers, heat exchangers, gas and air pressure piping and fittings, starting and reversing arrangements.

Where gas turbines operate in conjunction with free piston gas generators, the following parts of the latter are to be opened and examined: the gas and air compressor cylinders and pistons and the compressor end covers, the valves and valve gear, fuel pumps and fittings, synchronising and control gear, cooling system, explosion relief devices, gas and air piping, receivers and valves including by-pass. The manœuvring of engines is to be tested under working conditions.

## Section 8

### ELECTRICAL EQUIPMENT

**801** At each Special Survey the electrical equipment is to be examined and tested in accordance with 802 to 810.

NOTE.—In cases where the Committee have consented to Continuous Surveys, the electrical equipment may also be included in the survey cycle. (*See* B 808.)

**802** A test for insulation resistance is to be made on the cables, switchgear, generators, motors, heaters, lighting fittings, etc., and the insulation resistance is to be not less than 100,000 ohms between all insulated circuits and earth. The installation may be sub-divided to any desired extent by opening switches, removing fuses or disconnecting appliances for the purpose of this test.

**803** The fittings on main and emergency switchboards, section boards and sub-distribution fuse boards are to be examined and over-current protective devices and fuses inspected to verify that they provide suitable protection for their respective circuits.

**804** Generator circuit breakers are to be tested, as far as practicable, to verify that the protective devices including preference tripping relays, if fitted, operate satisfactorily.

**805** The electric cables are to be examined as far as practicable without undue disturbance of fixtures or casings unless opening up is considered necessary as a result either of observation or of the tests required by 802.

**806** The generator prime movers are to be surveyed as required by C 6 and C 7 and the governing of the engines tested. The motors concerned with essential services together with associated control and switch gear are to be examined and if considered necessary are to be operated as far as practicable under working conditions. All generators and steering gear motors are to be examined and are to be operated under working conditions though not necessarily under full load or simultaneously.

**807** Where transformers or electrical apparatus associated with supplies to essential services are oil-immersed, the Owners are to arrange for samples of oil to be taken and tested for breakdown voltage, acidity and moisture by a competent testing authority and a certificate giving the test results is to be furnished to the Surveyor.

**808** Where electro-magnetic couplings are fitted, the air gaps are to be measured and reported and any excessive eccentricity corrected. The couplings and associated switch gear are to be examined and tested.

**809** Navigation light indicators are to be tried under working conditions and correct operation on the failure of supply and failure of navigation lights verified.

**Electric Propelling Machinery**

**810** Where the ship is electrically propelled, the propulsion motors, generators, cables, and all ancillary electrical gear, exciters and ventilating plant (including coolers) associated therewith are to be examined and the insulation resistance to earth is to be tested. Special attention is to be given to windings, commutators and slip-rings. The operation of protective gear and alarm devices is to be checked as far as practicable. Insulating oil, if used, is to be tested in accordance with 807. Interlocks intended to prevent unsafe operations or unauthorised access are to be checked to verify that they are functioning correctly. Emergency overspeed governors are to be tested.

## Section 9

### BOILER SURVEYS

**901** All boilers, including exhaust gas or steam heated steam generators, economisers, domestic boilers having a working pressure exceeding 3,5 kg. per $cm^2$, and a heating surface exceeding 4,65 square metres, also press boilers and similar apparatus in floating whale oil factories are to be surveyed at two-yearly intervals until they are 8 years old and subsequently annually. In boilers employing forced circulation the pumps used for this service are to be opened and examined at each boiler survey.

**902** At the surveys described in 901 the boilers, superheaters, economisers and air heaters are to be examined internally and externally and where considered necessary the pressure parts are to be tested by hydraulic pressure and thickness of plates and tubes and size of stays are to be ascertained to determine a safe working pressure. The principal mountings on boilers, superheaters and economisers are to be opened up and examined and the safety valves adjusted under steam to a pressure not greater than 3 per cent above the approved working pressures of the respective parts. The remaining mountings are to be examined externally and are to be opened up for internal examination if considered necessary by the Surveyor. Collision chocks, rolling stays and boiler stools are to be examined and maintained in efficient condition.

**903** The oil fuel burning system is to be examined under working conditions and a general examination made of fuel tank valves, pipes, deck control gear and oil discharge pipes between pumps and burners.

**904** At each survey of a cylindrical boiler which is fitted with smoke tube superheaters, the saturated steam pipes are to be examined as detailed in C 1004.

## Section 10

### STEAM PIPES

#### Steel Pipes

**1001** INCIDENCE OF SURVEYS.—Saturated steam pipes, also superheated steam pipes where the temperature of the steam at the superheater outlet is not over 454° C., are to be surveyed at the second and each subsequent Special Survey. Superheated steam pipes where the temperature of the steam at the superheater outlet is over 454° C. are to be surveyed at each Special Survey, including the first.

SCOPE OF SURVEYS

**1002** PIPES HAVING BOLTED JOINTS.—At each survey a selected number of main steam pipes, also of auxiliary steam pipes over 75 mm. internal diameter supplying steam for essential services at sea, are to be removed for internal examination and hydraulically tested to twice the working pressure. If these selected pipes are found satisfactory in all respects, the remainder need not be tested. The pipes are, so far as practicable, to be selected for examination and hydraulic test in rotation so that in the course of surveys all sections of the pipeline will be tested.

**1003** PIPES HAVING WELDED JOINTS.—Where main and/or auxiliary steam pipes of the category described in 1002 have welded joints between lengths of pipe and/or between pipes and valves, the lagging in way of the welds is to be removed, the welds examined and, if considered necessary by the Surveyor, crack detected. Plugs fitted in the piping for inspection purposes are to be removed and the piping examined internally as far as practicable by introscope or other optical means and, after the plugs have been replaced, the pipe lines are to be tested hydraulically to twice the working pressure. Where lengths having ordinary bolted joints are fitted in such pipe ranges and can be readily disconnected, they are to be removed for internal examination and hydraulically tested to twice the working pressure.

**1004** CYLINDRICAL BOILERS HAVING SMOKE TUBE SUPERHEATERS.—Where the saturated steam pipes adjoining the saturated steam headers are situated partly in the boiler smoke boxes, all such pipes adjoining and cross-connecting these headers in the smoke boxes are, at the surveys required by 1001, to be included in the pipes selected for examination and testing as defined in 1002. Where the saturated steam pipes inside the smoke boxes consist of steel castings of substantial construction, these requirements need only be applied to a sample casting. Where steel castings are not fitted, the Surveyor is to satisfy himself of the condition of the ends of the saturated steam pipes in the smoke boxes *at each boiler survey* and, if he considers necessary, a sample pipe is to be removed for examination.

**1005** As an alternative to the requirements of 1002, and provided the saturated steam pipes in smoke boxes are dealt with as detailed in the first paragraph of 1004, the remainder of the pipes may, if the Owner wishes, be hydraulically tested in place to twice the working pressure. Lagging is to be removed as required by the Surveyor to permit effective examination.

**Copper Pipes**

**1006** At the second and at each subsequent Special Survey all copper steam pipes over 75 mm. internal diameter supplying steam for essential services at sea are to be hydraulically tested to twice the working pressure. At these surveys any of the pipes which may be subject to bending and/or vibration, such as those having expansion or other bends, and closing lengths adjacent to steam driven machinery, are to be annealed before being tested.

## Section 11

### SCREW SHAFTS AND TUBE SHAFTS

**1101** Screw shafts and tube shafts are to be drawn periodically for examination by the Society's Surveyors.

Where shafts are fitted with continuous liners or approved oil glands, or are made of approved corrosion-resisting material, they normally become due for survey at intervals of 3 years for single screw ships and 4 years for ships having two or more screws. All other shafts should be drawn at intervals of 2 years.

**1102** On the application of Owners, surveys of shafts of single screw ships having continuous liners or approved oil glands, or made of approved corrosion-resisting material may be held at intervals of 4 years, provided the keyway is of the sled-runner or round-ended type having adequate root radius and the edges rounded at the surface of the shaft and, at each survey, the shaft is examined by an efficient crack detection method over a length from the after end of the liner (or after end of the stern tube for shafts not fitted with continuous liners), to a position at about one-third of the length of the cone from the large end. Upon application by the Owners and provided the keyway is as described above, a four-year period will also be allowed before the first survey of the shaft of a new single screw ship and may be allowed for a new or previously unused spare shaft fitted to an existing ship. At the first and subsequent periodical surveys the forward portion of the shaft cone is to be examined by an efficient crack detection method.

**1103** The Committee will be prepared to give consideration to the circumstances of any special case upon application by the Owners.

## Section 12

### CLASSIFICATION OF SHIPS NOT BUILT UNDER SURVEY

**1201** When classification is desired for a ship not built under the supervision of the Society's Surveyors, application should be made to the Committee in writing.

**Hull and Equipment**

**1202** Plans showing the main scantlings and arrangements of the actual ship and any proposed alterations are to be submitted for approval. These should comprise midship section, longitudinal section and decks, and such other plans as may be requested. If plans cannot be obtained or prepared by Owners, facilities are to be given for the Society's Surveyor to take the necessary information from the ship.

Particulars of the process of manufacture and testing of the material of construction should be furnished.

**1203** In all cases the full requirements of C 201 to C 230 are to be carried out. In the case of tankers the requirements of C 301 to C 306 are also to be carried out. Tankers over 12 years old are in addition to comply with C 307, and other ships over 20 years old with C 231 and C 232. During the survey the Surveyors are to satisfy themselves regarding the workmanship and verify the approved scantlings and arrangements. For this purpose, and in order to ascertain the amount of any deterioration, parts of the structure will require to be drilled as necessary. Full particulars of the anchors, chain cables and equipment are to be submitted.

Ships of recent construction will receive special consideration.

**1204** When the full survey requirements indicated above cannot be completed at one time, the Committee may consider granting an interim record for a limited period. The conditions regarding the completion of the survey will depend on the merits of each particular case, which should be submitted for consideration.

**Machinery**

**1205** To facilitate the survey, plans of the following items, together with the particulars of the materials used in the construction of the boilers, air receivers and important forgings should be furnished:—

General pumping arrangements, including air and sounding pipes. (Shipbuilder's plan.)
Pumping arrangements at the forward and after ends of oil tankers and drainage of cofferdams and pump rooms.
General arrangement of cargo piping in tanks and on deck of oil tankers.
Piping arrangements for cargo oil (F.P. above 65,5° C.).
Bilge, ballast and oil fuel pumping arrangements in the machinery space, including the capacities of the pumps on bilge service.
Arrangement and dimensions of main steam pipes.
Arrangement of oil fuel pipes and fittings at settling and service tanks.
Arrangement of oil fuel piping in connection with oil burning installations.
Oil fuel and cargo oil overflow systems, where these are fitted.
Arrangement of boiler feed systems.
Oil fuel settling, service and other oil fuel tanks not forming part of the ship's structure.
Plans of machinery space piping are to be diagrammatic.
Boilers, superheaters and economisers.
Air receivers.
Crank, thrust, intermediate and screw shafting.
Clutch and reversing gear with methods of control.
Reduction gearing.
Electrical circuits.

NOTE.—Plans additional to the above should not be submitted unless the machinery is of a novel or special character affecting classification.

Where centralised, bridge or automatic controls are fitted to propulsion machinery and essential auxiliaries, a description of the scheme is to be submitted. Particulars are to be given of the spare gear carried for machinery and control gear and whether maintenance is by repair or replacement.

TORSIONAL VIBRATION CHARACTERISTICS

For new ships and ships which have been in service less than 8 years calculations of the torsional vibration characteristics of the propelling machinery are to be submitted for consideration as required for ships constructed under Special Survey. For older ships the circumstances will be specially considered in relation to their service record and type of machinery installed.

Where calculations are not submitted the Committee may require that the machinery certificate be endorsed to this effect.

When desired by the Owners the calculations and investigation of torsional vibration characteristics of machinery may be carried out by the Society upon special request.

**1206** The main and auxiliary machinery, also feed pipes, compressed air pipes and boilers are to be examined as required at Special Surveys, and their working pressures are to be determined from their actual scantlings in accordance with the Rules.

The screw shaft is to be drawn and examined.

The steam pipes are to be examined and tested as required by C 10.

The bilge, ballast and oil fuel pumping arrangements are to be examined and amended as necessary to comply with the Rules.

Oil burning installations are to be examined as required at Special Surveys and found, or amended, to comply with the requirements of the Rules ; they are also to be tested under working conditions.

The electrical equipment is to be examined as required at Special Surveys.

The fire extinguishing arrangements are to be in accordance with the Requirements of the Rules (*see* Chapter F).

The whole of the machinery, including essential controls, is to be tried under working conditions to the Surveyors' satisfaction.

First entry reports are to be prepared by the Surveyors.

**Periodical Surveys**

**1207** Periodical surveys are subsequently to be held as in the case of ships built under survey.

*1st October, 1964*

# Chapter D

# STEEL SHIPS

## Section 1

### GENERAL

**Determination of Scantlings**

**101** The scantlings in the Tables are related in general to basic dimensions and, where necessary, to a basic moulded draught. Corrections are given in the Tables, or associated notes, for use where the actual dimensions or draught of the ship differ from those in the Tables. The Rules and Tables are framed for ships of normal ratio of breadth to depth and having proportions of length to depth at the strength deck not exceeding thirteen and a half.

If the proportions are abnormal, special structural arrangements will be required.

The minimum scantlings given by the Tables may require to be increased on account of particular features in general design or when Owners desire to make provision for exceptional distributions or concentration of loading (*see* B 101, D 34, D 37 and Table 18, note 2 (*e*)).

The scantlings and arrangements in passenger ships will be specially considered in relation to the general design features.

**Assignment of Class**

**102** The Class 100A1 will be assigned in accordance with the provisions of Chapter B to all sea-going ships when the requirements of the Rules have been complied with for the draught required.

**Material**

**103** The Rules and Tables are based on the use of mild steel which complies with the requirements of Chapter P. Grade A steel (*see* P 2 Table II) may be used except where a higher grade is specifically required. As an alternative to Grade D, Grade C may be accepted, subject to compliance with the impact test requirements of Grade D. In special circumstances impact tests may not be required.

Where the physical characteristics of the steel are in excess of the requirements of P 2, or other material is used, the scantlings will be specially considered. For scantling reductions when higher tensile steel complying with P 219 to P 227 is used, *see* D 65, D 66 and D 67.

The minus tolerance in the thickness of plates and sections from those given on the approved plans is not to exceed 2 per cent. For plates below 25 mm. in thickness a plate edge thinning up to 0,5 mm. may be accepted if the average thickness of the plate is within the above minus tolerance limit.

The general standard as laid down by the Rules is to be maintained.

**Method of Construction**

**104** The Rules and Tables set forth requirements for riveted construction together with certain modifications where electric arc welding is adopted.

Particulars indicating the principal parts which are electrically welded will be given in the Register Book as deemed desirable by the Committee.

**Interpolation**

**105** For dimensions and draughts between the values given in the Tables the scantlings are to be obtained by interpolation.

**Distribution of Material**

**106** The scantlings given in the Tables for the midship portion of the ship are to be reduced gradually to those given for the ends.

**Equivalents**

**107** Alternative arrangements or fittings which are considered to be equivalent to the requirements of the Rules will be accepted by the Committee but the Owners' sanction may be required.

**Submission of Plans**

**108** For each ship proposed to be built under survey for classification in the Register Book plans of midship and longitudinal sections, on which the designed summer moulded draught is to be given together with the particulars necessary for calculation of freeboard, are to be submitted for approval.

The following plans are also to be submitted:—

Shell plating.
Decks.
Watertight bulkheads.
Pillars and girders.
Deep tanks.
Oil fuel bunkers.

Arrangements to resist panting.
Strengthening of bottom forward.
Rudder and sternframe.
Propeller brackets.
Bossed framing.
Motor and thrust seating.
Cruiser stern.
Long deckhouses.
Hatchways.
Main steering gear of rod and chain type and auxiliary steering gear.
Strengthening for navigation in ice.
Pumping arrangements.
Scheme of riveting.
Scheme of welding.

NOTE.—*It is recommended that a plan be carried in the ship ndicating the positions and grades (other than Grade A) of hull structural steel, for the convenience of all concerned with repairs and renewals. This may be done by colouring the plan according to P 202, or by other appropriate means.*

## Section 2

### DEFINITIONS

**201 Length L** is the distance in metres on the summer load waterline from the fore side of stem to the after side of rudder post, or to the centre of rudder stock if there is no rudder post, but L is not to be less than 96 per cent of the extreme length on the summer load waterline.

Amidships is to be taken as the middle of the length L.

**202 Breadth B** is the greatest moulded breadth in metres.

**203 Depth D** is measured in metres at the middle of the length L from top of keel to top of deck beam at side.

D for shell and topside plating is measured to the strength deck as defined in 207.

D for framing is measured to the uppermost continuous deck.

**204 Draught d** is the summer draught in metres measured from top of keel.

**205 Depth h for Framing** is measured in metres from the top of the double bottom or single bottom floor at side to the top of beam at side of the lowest deck.

**206 Effective Superstructure** is a midship superstructure extending from side to side of the ship and exceeding 0,15L in length.

**207 Strength Deck** is the uppermost continuous deck except in way of an effective superstructure where the superstructure deck is to be considered the strength deck.

**208 Passenger ship** is a ship, engaged on international voyages, which carries more than twelve passengers.

## Section 3

### KEELS, STEMS AND STERNFRAMES

#### Materials

**301** Steel castings are to comply with the requirements of P 5.

**302** Forgings made of ingot steel are to comply with the requirements of P 6.

**303** If forgings are made from scrap material, either iron or steel scrap may be used, but a mixture of iron and steel is not permitted.

#### Plate Keels

**304** The scantlings of plate keels are given in Table 14, note 1. Plate keels are to be associated with centre keelsons or centre girders as required by D 4 or D 5.

#### Bar Keels

**305** The scantlings of bar keels are given in Table 1.

Riveted scarphs connecting the separate lengths together, or to the stem and sternpost, are to have a length of nine times the thickness of the bar.

#### Stems

**306** Bar stems are to have the scantlings given in Table 1, but above the load waterline the dimensions may be gradually tapered to the stem head where the sectional area may be 75 per cent of the area derived from the Table.

**307** If the stem is constructed of shaped plates the thickness of the plates below the load waterline is to be 10 per cent greater than the thickness of the side shell plating given in Table 14, col. 6, without corrections; above the load waterline the thickness may be gradually tapered towards the stem head where it may be equal to the shell plating at ends. Plates which require to be furnaced are to have these thicknesses when finished.

The plates are to be supported by horizontal webs between the decks and below the lowest deck; the unsupported length of the stem plates is not to exceed 1,5 metres. Where the radius of the plates is large a centre line stiffener may be required.

For strengthening of plate stems for navigation in ice, *see* D 1008, D 1016 and D 1024.

**308** The separate lengths of the stem are to be efficiently connected and the lower end of a bar stem is to overlap the forward flat keel plate.

**Sternframes**

**309** Sternframes may be of rectangular or streamlined section or may be of built construction to suit the lines of the ship. The scantlings are to be determined from Tables 2 and 3 and associated notes. Cast steel and built sternframes are to be strengthened at intervals by transverse webs of suitable thickness. Cast steel sternframes are to be simple in design and all fillets should have a large radius.

**310** The lower part of the sternframe is to be extended forward to provide an efficient connection to the flat plate keel.

**311** The rudder post is to be attached to a transom plate of the same depth as that required for double bottom floors and 2,5 mm. thicker than the floors (*see* Table 6, cols. 4 and 10); when the length of the ship exceeds 91,5 metres the rudder post is to be connected to the transom by double angles, double riveted in each flange. In single screw ships having cruiser sterns or exceeding 91,5 metres in length the propeller post is to be efficiently attached to a deep floor.

**312** The sole piece under a propeller aperture is to be kept as short as possible and is to be increased in scantlings as required by Table 2, note 4.

**313** The upper gudgeon is to be as near as practicable to the rudder trunk and rudder coupling. Gudgeons are to have a thickness of metal round the finished bore equal to half the diameter of the pintle and the depth is to provide full bearing surface for the pintle. The scantlings of pintles are to be determined from Table 47 and associated notes.

**314** The length of the scarph in a sternframe of rectangular section is to be three times the fore and aft dimension of the post and the width of the scarph is to be half the length of the scarph. The thickness at the tip of the scarph is to be 13 per cent of the thickness of the post, and the connection is to be made by four rows of rivets. In single screw ships the scarph of the rudder post should not be fitted above the upper gudgeon. The strength of scarphs or other connections in cast steel streamlined sternframes is to be equivalent to the above requirements.

**315** The scantlings and arrangements of propeller brackets and of sternframes in ships of relatively high power will be specially considered.

**Cross-reference**

**316** For riveted connections to stems and sternframes, *see* Table 52 H.

## Section 4

### SINGLE BOTTOMS

**Floor Plates**

**401** The scantlings of floor plates are to be determined from Table 4 and associated notes. Floors are to be fitted at every frame.

If a bar keel is fitted the floors are to be continuous from side to side; if a flat plate keel is adopted the floors may be continuous or cut at the centre line.

**402** The floors at the bilges are to be attached to the frames by flanged brackets of the same thickness as the floor plates and having breadth and depth, clear of the frame and floor respectively, equal to the depth of the floor at the centre line.

Alternatively, the brackets may be omitted if the depth of the floor is increased by 15 per cent and the frame is reinforced at its junction with the floor plate.

**403** The tops of floors are, in general, to be level from side to side but in ships having considerable rise of floor, and in all ships in the engine room and towards the ends, the depth of the floor plates is to be increased; the brackets may be dispensed with provided the side framing is adequately supported.

**404** Floor plates forming part of a bulkhead are to be not less than 900 mm. in depth measured at the centre line and the thickness is to be as required for the bottom strake of the bulkhead.

**405** The side frames are to be efficiently attached to the floor plates.

**Frames and Reversed Frames**

**406** Floors are to be attached to the bottom plating by single angles having the same thickness as the floor plates. (*See* D 807.)

**407** Reversed frames on the upper edges of the floor plates are to have the scantlings given in Table 4.

Throughout the engine room, under the boiler bearers and in way of strengthening of bottom forward, the reversed frames are to be doubled from side to side.

**Centre Keelsons**

**408** The scantlings of centre keelsons are given in Table 5. The keelsons are to extend as far forward and aft as practicable, and where cut at bulkheads the longitudinal strength is to be efficiently maintained.

**409** In ships having a bar keel, the centre keelson is to consist of continuous double angles on top of the floors in conjunction with intercostal plates connected to the floors by single angles having the same thickness as the intercostal plates.

In ships not exceeding 50 metres in length the intercostal plates may be omitted provided the centre keelson bars are as required by Table 5 for tugs.

**410** Plate keels are to be associated with plate keelsons having double continuous top angles. The keelson plates are to be connected to the keel by single angles except in the engine room, thrust recess and the forward 0,25L where the connection is to be double. If the floors are continuous the keelson plates are to be intercostal and attached to the floors by single angles having the same thickness as the intercostal plates.

Where the floors are cut at the middle line they are to be connected to the continuous keelson plate by double angles having the thickness of the keelson plates. Continuous foundation plates are to be fitted at the top of the floors on each side of the keelson plate.

**411** The butts of all continuous longitudinal material are to be efficiently strapped or welded.

**Side Keelsons**

**412** The scantlings of side keelsons are given in Table 5. The keelsons are to extend as far forward and aft as practicable, and where cut at bulkheads the longitudinal strength is to be efficiently maintained.

**413** One side keelson is to be fitted on each side of the centre line if the breadth B does not exceed 9,15 metres and two where B is above 9,15 metres and does not exceed 16,45 metres.

**414** The keelsons are to consist of a continuous angle with the wider flange laying on the reversed frames.

Intercostal plates fitted between the floors are to be attached to the continuous angles and connected to the shell plating by single angles having the same thickness as the intercostal plates.

**415** The butts of the continuous angles are to be efficiently strapped or welded.

**416** In the engine room additional side keelsons are to be fitted.

**Increased Thicknesses in Machinery Spaces**

**417** In the engine room the floors are to be increased in thickness by 1 mm.

In the boiler room the floors, reversed frames, centre and side keelson plates and all angles not covered by cement are to be increased in thickness by 2,5 mm.

**Strengthening of Bottom Forward**

**418** The bottom structure forward is to be in accordance with the requirements of D 8.

**Ships Loading or Discharging Aground**

**419** It is recommended that the bottoms of small ships intended to load or discharge aground be additionally strengthened in order to withstand the exceptional stresses to which they may be subjected.

**Pumping and Drainage**

**420** The arrangements are to be in accordance with the requirements of Chapter E. Efficient provision is to be made to permit water from every part of the bottom to reach the pump suctions.

## Section 5

### DOUBLE BOTTOMS

**Scantlings**

**501** The scantlings of the double bottom structure and the tank side connections are to be determined from Tables 6 to 11 and associated notes.

**Centre Girder**

**502** The attachment of the centre girder to the keel plate and to the middle line strake of the inner bottom is to be by double angles, or equivalent connections, throughout in all ships exceeding 106,7 metres in length; in smaller ships the attachment need be double, or equivalent, only in the engine room, thrust recess and in the forward 0,25L.

**Intercostal Side Girders**

**503** In ships where the breadth B does not exceed 10,4 metres one stiffener is to be fitted to the floors on each side, about midway between the centre line and the margin plate. Where B exceeds 10,4 metres one intercostal side girder is to be fitted and where B exceeds 19,5 metres but does not exceed 24,4 metres two girders are to be fitted on each side of the centre line extending as far forward and aft as practicable. In the forward 0,25L of all ships side girders are to be fitted as required by D 805.

**504** In the machinery space and thrust recess the number and disposition of the side girders are to be such as to support the machinery effectively and to secure the necessary rigidity of structure. Double angles or equivalent connections are to be fitted on the upper edges of these girders under the engines and thrust seating.

**505** Intercostal girders are not to be flanged in the forward 0,25L under the engine and thrust seating or under widely spaced pillars. Where intercostals are flanged their thickness is to be increased by 10 per cent.

**506** If plate floors are fitted at every frame the intercostal girders, except in the engine room and in the forward 0,25L, may be replaced by continuous bulb angles on the shell and inner bottom, having the scantlings given in Table 10 for a span of 1,25 metres. These bulb angles are to be attached to the floors by vertical angles extending for the full depth of the floors and having the same depth as the bulb angles, but these angles need not exceed 150 mm. in depth. The thickness of the vertical angles may be the same as that of the floors.

Riveting at each end of the vertical angles is to be as required by Table 8, cols. 4 and 5.

### Plate Floors

**507** Plate floors are to be fitted at every frame in the engine room and in the forward 0,25L; they are also to be fitted under the boiler bearers, bulkheads, toes of brackets to deep tank bulkhead stiffeners and in way of any change in depth of double bottom. Partial plate floors are to be fitted under the thrust seating.

The floors under the engine room, thrust seating and boiler bearers are to have double angles or equivalent attachments to the centre girder; elsewhere the connections may be single. The reversed frames on the floors may be single except under the engine room from the centre line to the girder outside the engine seating, under the thrust seating and from side to side under boiler bearers.

**508** Except as required by 507, plate floors may be spaced not more than 3 metres apart, and the shell and inner bottom plating between these floors is to be supported by bracket floors. Alternatively a system of longitudinal framing may be adopted—*see* 517 to 523.

**509** Floors are not to be flanged.

**510** Watertight floors are to be fitted below or in the vicinity of watertight bulkheads and their thickness is to be 2 mm. greater than that given in Table 6, col. 10, but need not exceed 13,5 mm. If the depth of the centre girder exceeds 915 mm. the floors are to be fitted with stiffeners, of scantlings given in Table 9, spaced 760 mm. apart; the ends of the stiffeners are to extend to the toes of the boundary angles.

**511** Additional stiffening is to be fitted under the heels of widely spaced pillars as required by D 1516 to D 1523.

**512** In ships from which the cargo is to be regularly discharged by grabs, it is recommended that plate floors be fitted at every frame.

### Bracket Floors

**513** The scantlings of the bottom frames and reversed frames are to be determined from Table 7 and associated notes.

**514** The breadth of the brackets attaching the frames and the reversed frames to the centre girder and margin plate is to be three-quarters of the depth of the centre girder; the brackets are to be flanged on the unsupported edge and are to have the same thickness as the plate floors.

**515** The frames and reversed frames are to be attached to the side girders by angles having the same depth as the reversed frames, but these angles need not exceed 150 mm. in depth. The thickness of the vertical angles may be the same as that of the floors.

Struts, if fitted to reduce the unsupported span of the frames and reversed frames, are to have the scantlings given in Table 8. Where the struts are welded the area is to be at least 80 per cent of that given in Table 8, col. 6, provided their stability and end connections are adequate.

**516** Details of riveted connections in bracket floors are given in Table 8.

### Longitudinal Framing

**517** Where longitudinal framing is adopted in the double bottom the scantlings of the longitudinals are to be as given in Table 10 and associated notes.

**518** Plate floors are to be fitted at every frame under the main engines and the foremost shaft tunnel bearing and at alternate frames outside the engine seating or equivalent arrangements are to be provided.

Plate floors are also to be fitted under boiler bearers, bulkheads, and the toes of brackets of deep tank bulkhead stiffeners.

Elsewhere the spacing of the floors is not to exceed 3,65 metres or 0,05L and the thickness of the floors is to be increased 10 per cent beyond that required by Table 6.

The longitudinal girders under the main machinery are to extend for the full length of the machinery space and are to be carried aft to support the foremost shaft tunnel bearing; this extension abaft the after engine room bulkhead is to be at least three transverse frame spaces. At the fore end of the engine room the girders are to be tapered off over three transverse frame spaces and are to be efficiently scarphed into the longitudinal framing system.

**519** The floors are to be attached to the shell and inner bottom by double angles or equivalent for two spaces of longitudinals at each end of the floor plate. The floors are to be attached to the centre girder and margin plate by double angles single riveted, or equivalent, except where the spacing of the floors exceeds 2,45 metres when the attachment to the centre girder is to be by double angles double riveted.

**520** The unsupported span of the longitudinals is not to exceed 2,45 metres. In longer spans struts of the same scantlings as required for bracket floors (Table 8) are to be introduced and attached to the longitudinals by the number of rivets given in the Table. The scantlings of the longitudinals at shell and inner bottom adjacent to the centre girder and margin plate may be based on a span of 1,25 metres.

The shell and inner bottom longitudinals are to be attached to the floors by means of vertical angles extending from the shell to the inner bottom having the same depth as the inner bottom longitudinals, but these angles need not exceed 150 mm. in depth; they are to be riveted as required by Table 8. The thickness of the vertical angles may be the same as that of the floors.

Where longitudinals are cut at watertight floors they are to be attached to the floors by brackets of a width on each arm equal to three times the depth of the shell longitudinals, of the thickness given in Table 6, col. 10 or 11, and riveted as required by Table 8, cols. 7 and 8.

**521** An intercostal side girder, as required by 503 to 505, is to be fitted on each side where B exceeds 13,7 metres and two side girders on each side where B exceeds 21,3 metres.

**522** Between plate floors, transverse brackets of the thickness required by Table 6, col. 10 or 11, are to be fitted extending from the centre girder and margin plate to the adjacent longitudinal. The brackets, which are to be flanged, are to be fitted at every frame at the margin plate and those at the centre girder are to be spaced not more than 1,2 metres apart.

**523** Where, at the ends of the ship, the longitudinal system of framing is replaced by a transverse system adequate arrangements are to be made to avoid abrupt discontinuities.

### Inner Bottom Plating and Margin Plates

**524** The inner bottom plating is to be of the thickness given in Table 6 and is to be increased by 2 mm. under the hatchways if no ceiling is fitted; the thickness of the middle line strake is not to be less than that of the increased inner bottom plating.

The margin plate is to have the thickness given in Table 6 and is to be of the depth amidships required by Table 6, note 2.

**525** If cargo is to be regularly discharged by grabs, or similar means, it is recommended that double ceiling should be fitted or the thickness of the plating increased 5 mm. and fitted with a flush surface.

For recommendations for thickness of tank top plating when fork lift trucks are to be used, *see* D 1108.

**526** In passenger ships, the inner bottom plating is to be continued out to the ship's side in such a manner as to protect the bottom to the turn of bilge. Such protection will be deemed satisfactory if the line of intersection of the outer edge of the margin plate with the bilge plating is not lower at any part than a horizontal plane passing through the point of intersection with the frame line amidships of a transverse diagonal line inclined at 25 degrees to the base line and cutting it at a point one half the ship's moulded breadth from the middle line.

### Manholes and Lightening Holes

**527** Sufficient manholes are to be cut in the inner bottom, floors and side girders to provide adequate ventilation and access to all parts of the double bottom and the edges of the holes are to be smooth. No manholes are to be cut in the floors or girders under widely spaced pillars.

**528** Where manhole covers are attached by bolts to the inner bottom plating, doubling plates or rims are to be fitted to take the fastenings of the covers. Manhole covers which project above the inner bottom plating are to be adequately protected.

### Tank Side Brackets and Margin Connections

**529** The height and thickness of the tank side brackets are given in Table 11. The free edges of the brackets are to be flanged or otherwise stiffened.

At the ends of the ship where the form of the brackets may become unduly elongated, the arrangements will be specially considered.

**530** Riveted attachments of the tank side brackets to the frames and margin plate are given in Table 11. The angles attaching the floors to the margin plate are to have

the same number of rivets in both flanges as the angle to the tank side brackets, and the inner and outer angles are to be through riveted.

If gusset plates are fitted they are to be not more than three frame spaces apart; if the number of rivets required in the gusset is more than six per frame space the gusset is to be fitted at every frame or is to be a continuous plate. Gussets are to be so spaced that each will require not less than three rivets.

**531** If the margin plate is approximately horizontal the strength of the margin connection will be specially considered.

**532** For increases in the panting region, *see* D 906.

**Increased Thicknesses in Machinery Spaces**

**533** In the boiler room and donkey boiler recess the floor plates and brackets, centre and side girders, inner bottom plating, margin plate, tank side brackets, gussets and all rolled sections not covered by cement, and in the engine room the inner bottom plating, are to be increased in thickness as required in Tables 6 to 11 and associated notes.

**534** Where machinery is fitted aft, the thicknesses of the inner bottom plating in the boiler room are to be increased by the increments which would have been added if the machinery had been fitted amidships; in the engine room this thickness is to be as given in Table 6, col. 18.

**Strengthening of Bottom Forward**

**535** The bottom structure forward is to be in accordance with the requirements of D 8.

**Ships Loading and Discharging Aground**

**536** It is recommended that the bottoms of small ships intended to load or discharge aground be additionally strengthened in order to withstand the exceptional stresses to which they may be subjected.

**Oil Fuel**

**537** If oil fuel is to be carried in double bottoms the provisions of D 2020 and D 2021 are to be complied with.

Where refrigerated cargoes are to be carried, *see* D 2022 and D 2023.

**Pumping and Drainage**

**538** The arrangements are to be in accordance with the requirements of Chapter E.

**539** Ample provision is to be made for the free passage of air and water from all parts of the tanks to the air pipes and suctions.

**Caulking and Water Testing**

**540** The double bottom is to be caulked and made watertight, but the centre girder need not be caulked or tested.

Each compartment on completion is to be tested with a head of water representing the maximum pressure which could be experienced in service.

**Cross-reference**

**541** For additional stiffening under heels of pillars, *see* D 1520.

## Section 6

### SIDE FRAMING

**Scantlings**

**601** The scantlings of the main, peak and 'tween deck frames are to be determined from Tables 12 and 13 and associated notes.

The depth D for use in the Tables is defined in D 203.

**602** The scantlings given for the framing in the various 'tween decks represent the minimum standard, but the system is to be so arranged that continuity is maintained.

**603** Where holes are drilled or punched in the inboard flange of channel or similar hold frames, the scantlings may have to be increased.

**Frame Spacing**

**604** The spacing of the frames, except in the regions defined in 605 and 606, may be as given in Tables 12 and 13.

**605** Frame spacing in peaks and cruiser sterns is not to exceed the Table spacing or 610 mm., whichever is less.

**606** Frame spacing between 0,2L from forward and the collision bulkhead is not to exceed the Table spacing or 685 mm., whichever is less.

**607** Where the spacings adopted differ from those set forth in 604 to 606, the scantlings of the main and 'tween deck frames are to be corrected as required by the notes.

**Main Framing**

**608** The depth h to be used in Table 12 is defined in D 205, and is to be measured:

At amidships, for framing between the after peak bulkhead and 0,25L from the fore end.

At 0,25L from the fore end, for framing between that point and 0,15L from the fore end.

As required by D 905 for framing between 0,15L from the fore end and the collision bulkhead.

### Framing in 'Tween Decks and Superstructures

**609** In 'tween decks marked B (*see* notes to Table 13) between 0,12L from the after end and 0,2L from the fore end and in detached superstructures, frames may be fitted two frame spaces apart provided the main frame spacing does not exceed 760 mm. and the ratio of that spacing in millimetres to the minimum thickness of the 'tween deck side plating does not exceed 55 in ships 90 metres or less in length and 45 in ships 150 metres or more in length, with intermediate values in proportion.

**610** At each end of a bridge four frames are to extend from the 'tween deck below to the bridge deck.

**611** 'Tween deck and superstructure frames are to be efficiently scarphed to the main frames below or effectively attached to the deck, except in the poop where the lower ends of the intermediate frames (if fitted) need not be attached.

### Cruiser Sterns

**612** Cruiser sterns are to have frames of size required in peaks, and are to be additionally stiffened by web frames where required. The floor plates are to be of a reasonable depth, and are to be associated with a middle line girder.

### General

**613** Floors in fore and after peaks are to have a thickness 1 mm. greater than required for floors in a double bottom. In after peaks the floors are to extend well above the stern tube, or, if this is impracticable, cross-tie plates flanged on both edges are to be fitted above the stern tube. Rivets connecting floors and cross-tie plates to the frames are to be spaced not more than five diameters apart. (*See* D 908.)

**614** In boiler rooms and permanent coal bunkers the thickness of the framing is to be increased 1,5 mm. beyond that derived from the Tables.

**615** Where the depth of the framing is reduced adequate stiffness is to be maintained.

**616** The breadth of the shell flange of the frames is to be suitable for the diameter of rivet used.

### Cross-references

**617** For framing in deep water ballast tanks, in oil fuel bunkers and in machinery spaces, *see* D 19, D 20 and D 22.

## Section 7

## SHELL PLATING

### Scantlings

**701** Scantlings of flat plate keel and of garboard strakes with a bar keel are given in Table 14, notes 1 and 2.

**702** The thicknesses of bottom and side shell plating are to be determined from Table 14 and associated notes. The depth D for use in the Table is defined in D 203.

**703** In way of an effective superstructure the thickness of bottom and side plating may be based on D measured to superstructure deck, but clear of the superstructure D is to be taken to the uppermost continuous deck. The thicker plating is to be suitably extended within the ends of the superstructure to ensure continuity of strength. (*See* 710.)

**704** The scantlings of the sheerstrake are to be in accordance with Table 18 and D 1101.

### Openings in Shell Plating

**705** All openings in the shell plating for cargo doors, inlets, or other purposes, are to have well rounded corners, and arrangements are to be made to maintain the strength in way of the openings; the plating is to be reinforced in way of hawse pipes.

**706** Where side scuttles or other openings are cut in the sheerstrake, removing more than 20 per cent of the Rule sectional area of the unpierced plate, compensation is to be provided.

### Shift of Riveted Butts

**707** The butts of shell plates and those of sheerstrake and stringer plates are to be arranged to give as good a shift as practicable; in adjoining strakes butts are to be generally at least two frame spaces apart.

The butts of the sheerstrake are to be at least two frame spaces from those of adjacent deck stringer plates.

### Welded Construction

**708** In ships having transverse framing, if the seams and butts of the bottom shell plating are flush welded and the floor angles are riveted to the bottom shell then the thickness of the bottom plating is to be increased for 0,4L amidships by 5 per cent above the requirements of Table 14 and associated notes.

If the seams and butts of bottom shell plating are flush welded and the floors are welded to the shell, the thickness of the bottom plating is to be increased for 0,4L amidships by 15 per cent above the requirements of Table 14 and associated notes.

In addition to the provisions of D 503, the following stiffening is to be fitted to the bottom shell for 0,4L amidships with either system of construction:—

| | |
|---|---|
| Beam not exceeding 15,25 metres. | Two longitudinal stiffeners p. & s. |
| Beam above 15,25 metres and not exceeding 16,75 metres. | Four longitudinal stiffeners p. & s. |
| Beam above 16,75 metres and not exceeding 19,5 metres. | Three longitudinal stiffeners, and one intercostal side girder p. & s. |

Special consideration will be given to ships having greater beam.

The stiffeners are to be $150 \times 90 \times 11,5$ ordinary angle toe welded to the plating and connected at their ends. The intercostal side girders are to be of scantlings given in Table 6.

This stiffening, in which the engine girder system may be incorporated, is to be suitably scarphed to the stiffening forward required by D 801 and D 805, and is to be tapered gradually at the aft end.

For quality of steel, *see* D 3104.

**Wood Belting**

**709** Wood belting and fenders are not to be through bolted to the shell plating.

**Continuity of Strength**

**710** Continuity of strength is to be maintained at the break of superstructures as required by D 1206 and D 1305 to D 1308.

## Section 8

### STRENGTHENING OF BOTTOM FORWARD

**Extent**

**801** The bottom structure is to be strengthened between 0,05L and 0,25L from the fore end. A sketch showing sections in way of the bottom forward is to be submitted.

**Shell Plating**

**802** The thickness of the three strakes next to the keel plate, or, in small ships, two strakes provided these cover the flat of bottom, is to be that given in Table 14, col. 8, increased by 30 per cent where the length of the ship does not exceed 135 metres and 15 per cent where the length is 200 metres; the increase at intermediate lengths to be in proportion. In ships with machinery aft not exceeding 90 metres in length the increase is to be 40 per cent and the keel plate is not to be less in thickness than the adjacent bottom plating.

The midship thickness of the above strakes is to be carried forward to the increased plating.

If the floors are welded directly to the bottom plating the latter is to be increased in thickness.

**Double Bottoms**

**803** Floors and intercostal girders are not to be flanged.

**804** Plate floors are to be fitted at every frame and are to be connected to the bottom plating by double angles, or equivalent connections, extending from margin to margin, or, in single bottom ships, to lower turn of bilge.

**805** The intercostal side girders are not to be more than 2,15 metres apart, the plating between them being supported by additional half-height intercostal girders carried as far forward as practicable.

**806** Where longitudinal framing is adopted in the double bottom the arrangements are to include plate floors fitted on alternate frames between 0,05L and 0,25L from the fore end and the spacing of longitudinal framing is to be in accordance with the requirements of D 606.

**Single Bottoms**

**807** The reversed frames are to be doubled and additional intercostal girders are to be fitted; in other respects the requirements for double bottoms are to be carried out where they apply.

**Riveting**

**808** The rivets in both flanges of the frame angles are to be spaced $5\frac{1}{2}$ diameters apart. The diameter of rivets in butts and seams of bottom plating is to be appropriate to the increased thickness of the plating, and the seams are to be double riveted.

## Section 9

### ARRANGEMENTS TO RESIST PANTING

**Extent**

**901** The structure is to be strengthened to resist panting for 0,15L from the fore end and abaft the after peak bulkhead.

**Forward of the Collision Bulkhead**

**902** Tiers of beams spaced 1,85 metres apart are to be fitted to alternate frames below the lowest deck and are to have the scantlings given in Table 15.

**903** Stringer plates of the scantlings given in Table 16 are to be fitted at each tier of beams. The stringer plates are to have double attachments to the shell plating. Alternatively, stringer plates of Table scantlings may be fitted inside the frames without attachment to the shell plating provided the stringer plate is stiffened on both edges, and the thickness of the shell plating is 10 per cent greater than the thickness given in Table 14, col. 7, where the length of the ship does not exceed 45 metres, and 25 per cent where the length is 105 metres or above; the increase at intermediate lengths is to be in proportion.

**904** Frames to which a beam is not fitted are to be attached to the stringer plate by brackets, having the same thickness as the beam knees and a depth of one-half the breadth of the stringer plate.

**Abaft the Collision Bulkhead**

**905** The strength of the side frames below the lowest deck for the distance defined in 901 is to be increased above that derived from Table 12 by 20 per cent where D is less than 10,7 metres and 5 per cent where D is 15,25 metres or greater, intermediate values by interpolation, the value of "h" for use in the Tables being the maximum between 0,15L from the fore end and the collision bulkhead, measured as defined in D 205.

**906** The strength of the attachment of the frames to the tank side brackets, of the tank side brackets to the margin plates and gussets, and of the gussets to the margin plate is to be increased by 20 per cent above the requirements of Table 11. The connection of the floors to the margin plate is to be the same as the connection of the tank side brackets to the margin plate, and, where riveted, the connecting angles inside the tank are to be on the same side of the floor as the outside connections, to take through rivets.

**907** Side stringers of the scantlings given in Table 16 are to be fitted in line with those forward of the collision bulkhead and are to extend aft for the distance defined in 901; they are to be attached to the shell by single riveted angles.

The side stringers may be omitted provided the shell plating is increased by the percentage given in 903.

**Abaft the After Peak Bulkhead**

**908** The structure is to be efficiently stiffened by deep floors and tiers of beams in association with stringers as required in the fore peak (Tables 15 and 16) except that these may be spaced 2,45 metres apart. In twin screw ships the frames abaft the propeller brackets and up to the lowest deck are to be attached to the shell plating by two rows of rivets or equivalent connections. (*See* D 613.)

Special arrangements may be required in single screw ships of high speed.

If, on account of the ship's form, the unsupported length of the frames exceeds 2,45 metres, additional stiffening may be required.

For details of welding in after peak tank structure *see* D 3110.

**Deep 'Tween Decks**

**909** If necessary, in ships with deep 'tween decks additional intercostal side stringers supported by web frames are to be fitted at the forward and after ends. The stringers may be omitted provided the thickness of the shell plating is suitably increased.

## Section 10

## STRENGTHENING FOR NAVIGATION IN ICE

**General**

**1001** Where owners contemplate operating the ship in the ice at a trimmed ballast waterline this is to be indicated on the plans in addition to the light waterline. All references to "light waterline" are then to be taken as applying to the "light" or "ballast" waterline whichever is the lower.

### CLASS 1

**Framing**

**1002** Intermediate frames are to be fitted over the full length of the ship. The strength of these frames is to be the same as the rule main frames unless stringers are fitted in accordance with D 1005 when the intermediate frames may be 75 per cent of the rule main frames. In the panting region and in deep tanks the modulus of the intermediate frame is to be determined from the modulus of the main frames before the increases required by D 905 and D 1909 are applied.

The intermediate frames are to extend from 915 mm. below the light waterline to 760 mm. above the load waterline. They are to be connected at their ends to the main frames by a horizontal member having the same scantlings as the main frames or equivalent arrangements are to be provided.

In the fore and after peaks the main and intermediate frames are to have the same modulus as the rule midship frame.

**Shell Plating**

**1003** For a distance 2,5B abaft the foward perpendicular and extending vertically from 610 mm. below the

light waterline to 760 mm. above the load waterline the thickness of the shell plating is to be 50 per cent greater than the rule midship thickness.

For the remainder of the length over the same vertical extent the thickness is to be 25 per cent greater than the rule midship thickness. The change of thickness is to take place gradually.

The increased thickness need not exceed 25,5 mm. but is not to be less than 12,5 mm.

When the s.h.p. exceeds 2,26 (L × B) the shell plating for a distance B abaft the forward perpendicular shall be increased by 1 mm. for each 500 h.p. excess over the above figure but need not exceed 25,5 mm. (The s.h.p. is to be indicated on the plan on which the shell plating is approved.)

**Riveting**

**1004** The seams of increased shell plating are to be at least double riveted. The diameter of the rivets used may be 3 mm. less than that required by Table 52A for the increased thickness of plating but is not to be less than that required for the rule thickness.

**Stringers**

**1005** The following requirements apply only when the intermediate frames are made 75 per cent of the main frames (*see* D 1002).

Abaft the collision bulkhead stringers of the scantlings given in Table 16 are to be fitted 1,85 metres apart for a distance 1,5B from the forward perpendicular.

The stringer next below the load waterline is to extend over the full length of the ship unless a deck is situated not more than 610 mm. below the load waterline.

**Rudder and Steering Arrangements**

**1006** The diameters of the rudder head and pintles are to be increased by 25 per cent above that required by Tables 44 and 47. The side plating and webs of double plate rudders are to be increased by 50 per cent above that required by Table 46. The gudgeons, remaining rudder items, coupling and steering gear are to be based on the increased rudder head or pintle.

In welded double plate rudders the horizontal and vertical webs are not to be welded direct to the side plates but are to be attached to flat bars or equivalent arrangements made to avoid a hard point.

The rudder head is to be protected by a suitable cruiser stern or other equivalent arrangements.

**Sternframe**

**1007** The strength of the rudder post and solepiece and the diameter of the rudder axle (if fitted) are to be increased by 25 per cent above rule requirements.

**Stem**

**1008** A solid stem of forged, rolled, or cast steel is to be fitted up to 760 mm. above the load waterline and the sectional area is to be 25 per cent greater than rule requirements.

Above this position a plate stem may be fitted and the thickness of plates at 760 mm. above the load waterline is to be 65 per cent greater than the rule midship thickness but need not exceed 25,5 mm. The thickness may be tapered to that of the normal plate stem (*see* D 307) at the upper deck. Plates which require to be furnaced are to have these thicknesses when finished.

The connections of the shell plating to the stem are to be flush.

**Cross-reference**

**1009** For machinery requirements *see* H 8.

## CLASS 2

**Framing**

**1010** Intermediate frames are to be fitted from the stem to 2,5B abaft the forward perpendicular, or to the point at which the load waterline has its greatest breadth, whichever is furthest aft. The strength of these frames is to be the same as the rule main frames unless stringers are fitted in accordance with D 1013, when the intermediate frames may be 75 per cent of the rule main frames. In the panting region and in deep tanks the modulus of the intermediate frames is to be determined from the modulus of main frames before the increases required by D 905 and D 1909 are applied.

The intermediate frames are to extend from 915 mm. below the light waterline to 760 mm. above the load waterline. They are to be connected at their ends to the main frames by a horizontal member having the same scantlings as the main frames or equivalent arrangements are to be provided.

In the fore and after peaks the main and intermediate frames are to have the same modulus as the rule midship frame.

**Shell Plating**

**1011** For a distance B abaft the forward perpendicular and extending vertically from 610 mm. below the light waterline to 760 mm. above the load waterline the thickness of the shell plating is to be 50 per cent greater than the rule midship thickness.

For the remainder of the length over the same vertical extent the thickness is to be 15 per cent greater than the rule midship thickness. The change of thickness is to take place gradually.

The increased thickness need not exceed 25,5 mm. but is not to be less than 12,5 mm.

When the s.h.p. exceeds 2,26 (L × B) the shell plating for a distance B abaft the forward perpendicular shall be increased by 1 mm. for each 500 h.p. excess over the above figure but need not exceed 25,5 mm. (The s.h.p. is to be indicated on the plan on which the shell plating is approved.)

**Riveting**

**1012** The seams of increased shell plating are to be at least double riveted. The diameter of the rivets used may be 3 mm. less than that required by Table 52A for the increased thickness of plating but is not to be less than that required for the rule thickness.

**Stringers**

**1013** The following requirements apply only when the intermediate frames are made 75 per cent of the main frames. (*See* D 1010.)

Abaft the collision bulkhead stringers of the scantlings given in Table 16 are to be fitted 1,85 metres apart for a distance 1,5B abaft the forward perpendicular.

The stringer next below the load waterline is to extend for a distance 2,5B abaft the forward perpendicular or to the greatest breadth of load waterline, whichever is greater, unless a deck is situated not more than 610 mm. below the load waterline.

**Rudder and Steering Arrangements**

**1014** The diameters of the rudder head and pintles are to be increased by 12,5 per cent above that required by Tables 44 and 47. The side plating and webs of double plate rudders are to be increased by 25 per cent above that required by Table 46. The gudgeons, remaining rudder items, coupling and steering gear are to be based on the increased rudder head or pintle.

In welded double plate rudders the horizontal and vertical webs are not to be welded direct to the side plates but are to be attached to flat bars or equivalent arrangements made to avoid hard points.

**Sternframe**

**1015** The strength of the rudder post and solepiece and the diameter of the rudder axle (if fitted) are to be increased by 15 per cent above rule requirements.

**Stem**

**1016** The sectional area of a solid stem is to be 15 per cent greater than rule requirements.

Where a plate stem is fitted the thickness of plates below a position 760 mm. above the load waterline is to be 65 per cent greater than the rule midship thickness but need not exceed 25,5 mm. Above this position the thickness may be tapered to that of the normal plate stem (*see* D 307) at the upper deck. Plates which require to be furnaced are to have these thicknesses when finished. The spacing of the horizontal webs below the load waterline is not to exceed 915 mm.

The connections of the shell plating to the stem are to be flush.

**Cross-reference**

**1017** For machinery requirements *see* H 8.

## CLASS 3

**Framing**

**1018** Intermediate frames of the scantlings given in Table 17 are to be fitted for a distance 1,5B abaft the fore perpendicular. They are to extend from 915 mm. below the light waterline to 760 mm. above the load waterline. They need not be connected at their ends.

**Shell Plating**

**1019** For a distance B abaft the forward perpendicular and extending vertically from 610 mm. below the light waterline to 760 mm. above the load waterline the thickness of the shell plating is to be 50 per cent greater than the rule midship thickness. This increased plating is to be tapered gradually into the midship plating so that the midship thickness is reached at the point where the load waterline is at the greatest breadth.

The increased thickness need not exceed 25,5 mm. but is not to be less than 12,5 mm.

**Riveting**

**1020** The seams of increased plating are to be at least double riveted. The diameter of rivets used may be 3 mm. less than that required by Table 52A for the increased thickness.

**Stringers**

**1021** For a distance 1,5B abaft the forward perpendicular stringers of the scantlings given in Table 16 are to be fitted 1,85 metres apart. The stringers may be omitted provided the intermediate frames are made equal in strength to the main frames.

**Rudder and Steering Arrangements**

**1022** The diameters of rudder head and pintles are to be increased by 7,5 per cent above that required by Tables 44 and 47. The side plating and webs of double

plated rudders are to be increased by 10 per cent above that required by Table 46. The gudgeons, remaining rudder items, coupling and steering gear are to be based on the increased rudder head or pintle.

**Sternframe**

**1023** The strength of the rudder post and solepiece and the diameter of the rudder axle (if fitted) are to be increased by 7,5 per cent above rule requirements.

**Stem**

**1024** The sectional area of a solid stem is to be 10 per cent greater than rule requirements.

Plate stems are to comply with D 1016.

The connections of the shell plating to the stem are to be flush.

**Cross-reference**

**1025** For machinery requirements *see* H 8.

## Section 11

### DECKS

**Plated Decks**

**1101** Strength deck and sheerstrake scantlings are to be determined from Table 18 and associated notes. The depth D for use in the Table is defined in D 203. Strength deck requirements are tabulated for ships having one, two or three decks. If there is more than one deck the sectional area of the strength deck given in Table 18 is that required when the scantlings of the lower decks are in accordance with Table 20.

**1102** Scantlings for effective superstructures, as defined in D 206, are also to be determined from Table 18, the depth D being measured to the superstructure deck. (*See* Table 18, note 8.)

**1103** Minimum thicknesses of strength decks and lower decks are given in Tables 18 and 20 respectively.

For quality of steel, *see* D 3104, D 3105 and D 3106.

**1104** Platform decks for which no credit is taken in determining the scantlings of the strength deck (*see* 1101) are to have the scantlings given in Table 20, col. 8.

**Decks with Stringer and Tie Plates**

**1105** The scantlings of stringers and tie plates fitted under a wood deck are to be determined from Table 18, note 9, and Table 20, note 5.

Tie plates are to be fitted at each side of the hatchways and are to be continuous; where these form the upper members of girders supported by widely spaced pillars they are to be suitably increased. Cross ties are to be arranged at the ends of hatchways and other openings. The decks are to be plated over abreast machinery openings, the plating being tapered into the stringer plates beyond the openings.

**Stringer Angles**

**1106** The butts of strength deck stringer angles are to be efficiently welded or strapped and if the angle is cut in way of scuppers compensation is to be provided.

**Concentration of Loading**

**1107** Additional strengthening to the decks may be required where there is indication of concentration of loading.

**Fork Lift Trucks**

**1108** Where Owners desire to make provision for the use of fork lift trucks it is recommended that the deck thickness should not be less than that given below:—

| Type of Truck | Total Weight of Truck and Load Metric Tons | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| | Minimum Deck Thickness (irrespective of beam or longitudinal spacing) Millimetres | | | | | | | | | | | |
| Two Wheels at Fork End ... ... | 7,5 | 9,0 | 10,0 | 11,0 | 12,0 | 12,5 | 13,5 | 14,0 | 15,0 | 15,5 | 16,0 | 16,5 |
| Four Wheels in pairs at Fork End ... | 6,5 | 7,5 | 8,0 | 9,0 | 9,5 | 10,5 | 11,0 | 11,5 | 12,0 | 12,5 | 13,0 | 13,5 |

Where Owners desire to use fork lift trucks on insulated decks or tank tops special consideration will be given to the permissible loading in association with the insulation arrangements and the plating thickness.

### Continuity of Strength

**1109** Continuity of strength is to be maintained at the ends of large openings in the strength deck and the deck below by means of corner doubling plates or equivalent arrangements, and associated, if necessary, with intercostal girders at the strength deck. Special attention is to be given to workmanship at these parts.

For welded construction, *see* D 3108.

### Wood Sheathing and Decks

**1110** The material is to be of good quality, well seasoned and free from sapwood. The thickness is to be not less than 65 mm. for pine or 50 mm. for teak.

Thwartship planks are to be laid at the ends of hatchways, deckhouses and similar boundaries.

The vertical flange of coaming or foundation angles is to extend 12,5 mm. above the wood deck. Gutterway angles or welded flats are to be not less than 7,5 mm. in thickness.

The planking is to be efficiently fitted. Fastenings are to be not less than 12,5 mm. in diameter, sunk below the surface of the planking and covered with turned dowels, the whole being thoroughly bedded in white lead or other suitable composition.

Bolts are to be galvanised; welded studs used instead of bolts are to be coated with suitable composition before the planking is laid.

All decks are to be caulked and payed.

### Deck Compositions

**1111** If an approved composition is laid as a substitute for wood sheathing the steel deck is to be caulked, made watertight and coated with a suitable material in order to prevent corrosive action between the steel and the composition. The composition is to be effectively secured to the deck. (*See* F 807 and F 1003).

### Caulking and Water Testing

**1112** All plated decks are to be caulked unless sheathed with a properly caulked wood deck. The spaces between frames at lower decks are to be effectively closed by cement or other means.

Weather decks and gutterways are to be hose tested on completion.

### Deck Loading

**1113** The Rule scantlings of decks are appropriate to the following cargo loads:—

(*a*) Upper Deck—A height of 1,25 metres and a stowage rate of 1,39 cubic metres per 1000 kg.

On the hatch the height is to be taken as 1,5 metres and 1,25 metres for Table 43A or Table 43B hatches respectively. (*See also* Note 7 of Table 43).

(*b*) Second and Lower Decks (*including the Hatch Covers*)—A height equal to the mean height of the part of the 'tween deck under consideration and a stowage rate of 1,39 cubic metres per 1000 kg.

(*c*) Decks Forming the Crown of a Tank—The greater of the values derived either in accordance with (*b*) or by taking a head equal to one half the height of the air pipe above the crown of the tank and a stowage rate of 0,975 cubic metres per 1000 kg.

Ships to which a timber load line is assigned are required to be specially strengthened (*see* D 1408 and D 1526) and Owners are referred to the Load Line Convention regarding the permissible height of timber deck cargo. Other ships may carry a timber deck cargo equivalent to a load of 2,29 metres at 1,39 cubic metres per 1000 kg.

## Section 12

## DETACHED SUPERSTRUCTURES

### Forecastles

**1201** All seagoing ships are to have forecastles except where the load draught is less than 0,7D. Where the omission of the forecastle may be necessary, increased sheer forward is to be provided as may be required by the Committee.

### Short Superstructures

**1202** The scantlings of poops and forecastles, and of bridges not exceeding 0,15L in length, are to be determined from Table 21 and associated notes.

All seams and butts may be single riveted.

### Long Bridges

**1203** A long bridge is an effective superstructure as defined in D 206, and the scantlings are to be determined from Table 18 and associated notes. (*See* D 703 and D 1102.)

Second and third deck scantlings may be reduced in way of the superstructure. (*See* Table 18, note 8.)

**1204** The riveting of butts and seams of deck plating, sheerstrake and side plating is to be as required by Table 52 B & C, but the side plating and sheerstrake seams are not to be less than double riveted for four frame spaces at the ends of the superstructure.

**1205** Transverse strength is to be ensured by fitting web frames or partial bulkheads in the bridge if large deckhouses are constructed above.

**Strengthening at Ends of Superstructures**

**1206** The thickness of the upper deck sheerstrake is to be increased by 50 per cent and the thickness of the stringer plate by 25 per cent at the ends of long bridges. Similar strengthening is to be fitted at the ends of poops or forecastles within 0,5L amidships.

At the ends of short bridges these increases are to be 30 per cent and 10 per cent respectively.

In way of a long bridge the upper deck sheerstrake, stringer plate and deck plating as fitted in the wells are to extend into the bridge for a distance equal to about one-third the breadth of the ship.

The bridge side strakes, which are to be increased 25 per cent in thickness at the ends of the superstructure, are to be tapered as far as practicable into the bulwark plating or upper deck sheerstrake; the plating is to be efficiently stiffened at its upper edge and supported by web plates not more than 1,5 metres from the end bulkhead.

**Bulkheads at Ends of Superstructures**

**1207** The bulkheads at the ends of poops, bridges, and forecastles are to have the scantlings and arrangements given in Table 22 and associated notes.

**Deckhouses**

**1208** All deckhouses are to be of sufficient strength and the scantlings of the ends, sides and of the top beams are to be in accordance with the requirements of Table 23 and associated notes. Beams and stiffeners should, as far as possible, be fitted in line with the main framing.

**1209** Where the length of single or two-tier deckhouses exceeds 0,15L, the sectional area of the top plating is to be derived from Table 23 and associated notes. In all ships above 91,5 metres in length the exposed decks over passenger accommodation are to be completely plated.

**1210** The sides and ends of the deckhouses are to be supported by partial bulkheads or web frames, spaced about 9,15 metres apart, and web frames are to be fitted, if practicable, at the sides of large openings.

Arrangements are to be made to minimise the effect of discontinuities in the deckhouse structure. All openings cut in the sides should be substantially framed and have the corners well rounded; continuous coamings are to be fitted below and above doors and similar openings.

Particular attention is to be given to the structure at the corners and ends of long deckhouses. Adequate support under the ends of the houses is to be provided in the form of web frames at ships' sides and diaphragms or pillars near the centre line in conjunction with reinforced deck beams. The corners of the deckhouses should be connected to the deck by double riveted or equivalent connections, which, if incorporating welding, will be specially considered.

The deckhouse sides are to be additionally stiffened in way of boats and the top strengthened in way of the davits.

**1211** Partial bulkheads or web frames are to be fitted in the 'tween decks below deckhouses and, where practicable, in continuation of watertight bulkheads below.

**Cross-reference**

**1212** For exposed casings protecting machinery openings, *see* D 22 and Table 23, note 11.

For scantlings of deck plating inside long deckhouses *see* Table 18, note 2 (*d*).

For aluminium superstructures, *see* F 812.

## Section 13

## RAISED QUARTER DECKS

**Scantlings in way of the Raised Quarter Deck**

**1301** The scantlings of shell, sheerstrake, stringer and deck plating are to be based on the depth D measured to the raised quarter deck.

**1302** The scantlings of side frames are to be based on the depth D measured to the upper deck with h measured to the raised quarter deck.

**1303** The scantlings of beams are to be determined using the depth D measured to the raised quarter deck.

**Break Bulkhead**

**1304** The front or break bulkhead of the raised quarter deck is to have the thickness of plating required for bridge front bulkheads and is to be sufficiently stiffened.

**Strengthening at Break**

**1305** The stringer plates of the upper or bridge deck and the raised quarter deck are to overlap for three or four frame spaces at either side of the break bulkhead according to the size and proportions of the ship.

**1306** Similarly in ships exceeding 67,1 metres in length the deck plating is to overlap for two or three spaces

and the stringers are to extend for two or three spaces beyond the plating.

**1307** Sufficient diaphragm plates, of the thickness of the break bulkhead, are to be fitted between the overlapped decks and connected to them and to the break bulkhead by double angles; the diaphragms are to be stiffened on their after edges and elsewhere if necessary.

**1308** The upper deck sheerstrake is to be increased in thickness by 40 per cent and extended for a reasonable distance abaft the break. The raised quarter deck sheerstrake is also to be increased in thickness by 30 per cent when connected to a long bridge and is to be extended into the bridge.

## Section 14

### BEAMS AND DECK LONGITUDINALS

#### Scantlings

**1401** The scantlings of deck beams at weather, cargo and accommodation decks are to be determined from Tables 24 and 25 and associated notes.

**1402** The scantlings of deck longitudinals are to be determined from Tables 26 and 27 and associated notes.

#### General

**1403** Beams are to be fitted at every frame.

**1404** Where hatch side coamings are more than 457 mm. from the deck girder the overhanging beams are to be reinforced, or the coamings are to be made sufficiently strong to act as girders to carry the ends of the beams and the load on the hatchway.

**1405** Beams or longitudinals at the crown of deep tanks, peak tanks and oil fuel tanks are to satisfy the requirements of Tables 24, 25, 26 or 27 and associated notes but are not to be less in strength than the standard required for the stiffeners of the boundary bulkheads to those tanks. (*See* D 1901 and D 2004.)

**1406** Where holes are punched in the face flange of channel or similar beams the modulus of the beams may require to be increased.

**1407** Weather decks are to be suitably cambered.

#### Timber Deck Cargoes

**1408** Where timber load lines are to be assigned the scantlings of deck beams at weather decks are to be in accordance with Table 24, note 6.

#### Beam Knees and Brackets of Deck Longitudinals

**1409** The scantlings of beam knees and brackets of deck longitudinals together with their riveted attachments are to be determined from Table 28.

**1410** Where intermediate frames in the 'tween decks are omitted the beam knees are to be attached to the shell plates by angles having the same thickness as the knees.

**1411** In ships having more than three tiers of beams and where large areas of deck are arranged for accommodation, or where particular conditions of loading are contemplated, the requirements for beam knees will be specially considered.

**1412** The riveted attachment of half beams to hatch side coamings and casings is given in Table 52 H.

#### Cross-references

**1413** For strong hatch end beams and deck transverses, *see* D 1512 to D 1515.

For strengthening in machinery spaces, *see* D 2207.

## Section 15

### DECK GIRDERS AND PILLARS

#### General

**1501** Deck beams are to be supported by longitudinal deck girders in association with pillars or strong hatch end beams.

Deck longitudinals are to be supported between bulkheads by transverses pillared as necessary.

For the forward 0,075L of forecastle and weather decks, longitudinal girders are not to be spaced more than 3,66 metres apart, and transverses not more than 2,44 metres apart. Girders are to have intercostal plates attached to the deck and are not to consist of angle runners.

Pillars in the 'tween decks and holds are to be in the same vertical line, as far as practicable.

The scantlings are to be determined from Tables 29, 30 and 31 and associated notes.

#### Special Loads

**1502** Where a girder is subject to concentrated loads, such as pillars out of line, the scantlings are to be suitably increased and the pillars which support the girder are to be strengthened to bear the portion of the concentrated load which they carry.

**1503** Where cargoes such as chilled meat are suspended from a deck which may be simultaneously loaded above, the scantlings of the girders are to be increased as required by Table 29, note 1 (*f*).

**1504** Additional attachments may be required to meet particular local stresses.

### Longitudinal Deck Girders

**1505** Girders are to be connected to the deck by angles of the same thickness as the web plate. If the span is greater than 9,15 metres in association with a normal height of 'tween deck, the deck connection is to be doubled for two beam spaces at each end.

**1506** Girders of unsymmetrical section are to be supported by tripping brackets at alternate beams; if the section is symmetrical the brackets may be four frame spaces apart. Where the unsupported width of the girder flanges is 150 mm. or greater the tripping brackets are to be connected to the face bar or flange. Where symmetrical sections are fitted tripping brackets are to be fitted on both sides. Intermediate beams are to be connected to the girders by lugs having the same thickness as the web plate and extending to the toe of the face bar or to the flange.

The thickness of deck plating in way of the girder is to be increased where necessary to provide an effective upper flange of the girder.

**1507** Girders are to be attached to the bulkhead by flanged brackets of the same thickness as the girder. The distance of the toe of the bracket below the deck is given in Table 29 and the horizontal arm is to be the same as the depth below the girder. The connections of the bracket to the girder and the bulkhead are to be double riveted.

**1508** Continuity is to be efficiently maintained over the heads of pillars, and the butts of longitudinal material in the girders are to be efficiently strapped or welded.

### Hatch Coamings

**1509** At lower decks side coamings acting as girders and not forming part of a continuous girder are to be extended for at least two frame spaces beyond the hatch end beams by short girders below the deck.

**1510** At weather decks deep hatch coamings which are intended to act as girders are to be extended beyond the hatchway ends in the form of brackets, the coamings below the deck being effectively connected to the hatch end beams. Where extension above the deck is not practicable the coaming below the deck is to be extended by short girders for at least two frame spaces beyond the hatch end beams.

For welded construction, *see* D 3108.

**1511** At the corners of all hatchways supported by hatch end beams horizontal gusset plates are to be fitted connecting the side coamings to the hatch end beams, and the vertical connections are to be double riveted or equivalent.

### Strong Hatch End Beams

**1512** Strong hatch end beams are to be supported at the centre line and attached to the side frames by brackets equivalent to the requirements of Table 29, and the frames are also to be strengthened if considered necessary.

**1513** The hatch end beams are to be connected to the deck plating by angles of the same thickness as the web plate and sufficient tripping brackets are to be fitted.

### Deck Transverses

**1514** Transverses supporting deck longitudinals are to be attached to the frames by brackets equivalent to the requirements of Table 29, and tripping brackets are to be fitted as required. The transverses are to be connected to the deck by angles of the same thickness as the web plates.

**1515** Longitudinals are to be attached to the transverses by lugs having the same thickness as the web plates and extending to the toe of the face bar.

### Pillars

**1516** Effective arrangements are to be made to distribute the loads at the heads and heels of all pillars.

**1517** Solid pillars may be attached to continuous runners, having scantlings given in Table 30, fitted under the deck beams. The runners are to be attached to each beam and to the bulkheads by angle lugs having two rivets in each flange. The heads and heels of the pillars are to have a bearing fit. At watertight and oiltight surfaces the heels are to be riveted to double angles or T bars or directly welded.

**1518** Tubular pillars are to be attached at their heads to suitable capital plates supported by brackets, flanged where necessary, in order to transmit the load effectively.

Doubling plates are to be fitted to the inner bottom under the heels of tubular pillars, and to decks under pillars of large diameter. The pillars are to have a bearing fit and are to be attached to the capital and doubling plates by riveted angle rings or by continuous welding.

**1519** At the heads and heels of pillars built of rolled sections the load is to be well distributed by means of longitudinal and transverse brackets.

**1520** In double bottoms under widely spaced pillars the connections of the floors to the intercostal girders and of the floors and girders to the inner bottom are to be suitably increased. Where pillars are not directly above the intersection of plate floors and intercostal girders, partial floors and intercostals are to be fitted as necessary to support the pillars. Manholes are not to be cut in the floors and girders below the heels of pillars.

Where longitudinal framing is adopted in the double bottom, equivalent stiffening under the heels of pillars is to be provided.

**1521** In ships carrying refrigerated cargoes and carrying oil fuel in the double bottom, the connections of the hold pillars to the inner bottom, including the doubling plates, are to be welded. (*See* D 2022.)

**1522** Where the heels of pillars are carried on a tunnel suitable arrangements are to be made to support the load.

**1523** Where pillars are fitted under watertight flats the end attachments are to be sufficient to withstand the load due to water pressure.

**1524** Additional pillars are to be fitted below deckhouses, windlasses, winches, capstans and elsewhere where considered necessary. The structure in way of the boat davits is to be strengthened.

### Machinery Spaces

**1525** Arrangements for supporting the structure in machinery spaces will be specially considered.

### Timber Deck Cargoes

**1526** Where timber load lines are to be assigned the scantlings of weather deck longitudinal girders, strong hatch end beams, deck transverses and pillars are to be in accordance with Table 29, note 6 and Table 31, note 6. Particular attention is to be paid to the end connections of girders and hatch end beams. (*See also* D 1408.)

### Cross-references

**1527** For centre line and bunker bulkheads supporting decks, *see* D 18.

For riveting, *see* Tables 31 and 52 H.

## Section 16

## WATERTIGHT BULKHEADS

### Number and Disposition of Transverse Bulkheads

**1601** All ships are to have a collision bulkhead, situated not less than 0,05L from the fore end of the load waterline, an after peak bulkhead enclosing the stern tubes in a watertight compartment and a bulkhead at each end of the machinery space.

When a coal cross bunker is situated at the forward end of the boiler space, its after bulkhead may be of non-watertight construction as required by D 18, provided the forward bulkhead complies with the requirements of this section for watertight bulkheads.

If this compartment is to be used for cargo, the after bulkhead is to be welded or riveted and caulked as required by this Section, and all openings are to be blanked off and made watertight. The requirements of D 29 are to be complied with, and bilge suctions and sounding pipes fitted as required for a separate hold compartment.

**1602** In ships exceeding 67,1 metres in length, additional watertight bulkheads are to be fitted so that the total number of bulkheads is in accordance with the following Table:—

| Length L | | Total number of bulkheads | |
|---|---|---|---|
| Above | Not exceeding | Machinery amidships | Machinery* aft |
| metres | metres | | |
| — | 67,1 | 4 | 3 |
| 67,1 | 86,9 | 4 | 4 |
| 86,9 | 102,1 | 5 | 5 |
| 102,1 | 112,8 | 6 | 5 |
| 112,8 | 123,4 | 6 | 6 |
| 123,4 | 143,3 | 7 | 6 |
| 143,3 | 164,6 | 8 | 7 |
| 164,6 | 185,9 | 9 | 8 |

* After peak bulkhead forming the after boundary of the machinery space.

**1603** The bulkheads in the holds should be spaced at reasonably uniform intervals. Where this is departed from and the length of a hold is unusually great, the tranverse strength of the ship is to be maintained.

**1604** The Committee will be prepared to consider proposals from owners to dispense with one or more of these bulkheads if they interfere with the requirements of a special trade, subject to suitable structural compensation.

### Height of Bulkheads

**1605** The collision bulkhead is to extend to the uppermost continuous deck.

**1606** The after peak bulkhead may terminate at the first deck above the load waterline provided this deck is made watertight to the stern or to a watertight transom floor.

**1607** The remaining bulkheads are to extend to the uppermost continuous deck except where the draught is not greater than that permitted with a superstructure extending for the full length of the ship above the second deck, when the bulkheads may terminate at that deck provided it lies above the load waterline.

In passenger ships of restricted draught the height of the bulkheads will be specially considered.

### Bulkhead Plating

**1608** The thickness of bulkhead plating is to be in accordance with Table 32 and associated notes.

**1609** The lowest strake is to be at least 900 mm. deep measured from the inner bottom, or from the keel if there is no double bottom; where an inner bottom terminates on a bulkhead the top of the lowest strake of the bulkhead is to be at least 300 mm. above the inner bottom. At stokehold bulkheads in coal burning ships the lowest strake is to extend at least 600 mm. above the stokehold platform.

### Bulkhead Stiffeners

**1610** The scantlings of vertical stiffeners having bracketed or lugged end connections are to be determined from Table 33 or 34 respectively, and associated notes. The scantlings of stiffeners which are bracketed at one end and lugged at the other may be taken as a mean between those required by Tables 33 and 34.

The scantlings for stiffeners in tugs are given in Table 35.

**1611** The Tables apply to stiffeners spaced 610 mm. apart at collision bulkheads and 760 mm. apart at other watertight bulkheads not forming boundaries of tanks. Scantlings are to be corrected as required by the notes for departures from Table spacing.

**1612** Where bulkhead stiffeners are cut in way of watertight doors in the lower part of a bulkhead the opening is to be suitably framed, and a tapered web plate, stiffened on its edge, is to be fitted on each side of the door from the base of the bulkhead to well above the opening.

Where stiffeners are not cut but the spacing between the stiffeners is increased on account of watertight doors, as in 'tween deck bulkheads, the stiffeners at the sides of the doorways are to be increased in depth and strength so that the efficiency is at least equal to that of the unpierced bulkhead, without taking the stiffness of the door frame into consideration.

**1613** Bulkheads are to be suitably strengthened if necessary at the ends of deck girders and where subjected to concentrated loads.

### End Attachments of Stiffeners

**1614** End brackets for stiffeners derived from Table 33 are to have dimensions, measured from the heel of the boundary angle to the toes of the bracket, equal to two and a half times the depth of the stiffener. The thickness of the brackets and the number of rivets required are given in Table 36.

The bracket or its connecting angle at the lower end of each stiffener is to extend to the floor adjacent to the bulkhead.

At each deck level which forms the top of a system of stiffeners plating is to be provided of a character which will ensure rigidity, and the attachments of the upper brackets on the hold stiffeners to this plating are to extend over a beam space.

Where the inner bottom is framed longitudinally the stiffeners of the bulkhead should be arranged, if practicable, over the longitudinals.

**1615** End lugs for stiffeners derived from Table 34 are to be of the same thickness as the boundary angles and are to be riveted as required by Table 36.

### Boundary Connections

**1616** Angles connecting bulkheads to shell, inner bottom and deck plating are to be 2,5 mm. thicker than the Table thickness of the bulkhead plating to which they are attached.

### Watertight Recesses and Flats

**1617** Watertight recesses in bulkheads are to be so framed and stiffened as to provide strength and stiffness equivalent to the requirements for watertight bulkheads.

**1618** Horizontal plating is to be 1 mm. thicker than required by Table 32 for watertight bulkheads at corresponding levels. The strength and stiffness of beams are to be equivalent to the requirements of Table 33 if cut and bracketed or continuous.

The thickness of plating and scantlings of beams are not to be less than required by D 11 and D 14.

### Longitudinal Bulkheads

**1619** Watertight longitudinal bulkheads are to be equal in strength and stiffness to the requirements for transverse bulkheads.

### Chain Lockers

**1620** Chain lockers fitted abaft the collision bulkhead are to be caulked and the space is to be efficiently drained.

### Riveting

**1621** Requirements for riveting are given in Table 52 H.

### Welded Stiffeners

**1622** The scantlings of welded stiffeners will be considered in accordance with note 3 to Tables 33 to 36.

### Watertight Doors

**1623** Watertight doors are to be efficiently constructed and fitted, tried under working conditions and hose tested in place. (*See* 1627.)

Provision should be made to ensure that coal will not impede the satisfactory operation of bunker doors.

**1624** Watertight doors are to be capable of being quickly closed from an accessible position above the bulkhead deck, and are to have an index at the operating position showing whether the door is open or closed. Hand gear is to have an all-round motion. The lead of shafting is to be as direct as possible and the screw is to work in a gunmetal nut.

**1625** Hinged watertight doors of approved pattern may be fitted in 'tween decks in approved positions. The hinges of these doors are to be fitted with gunmetal pins.

### Caulking and Testing

**1626** Watertight bulkheads, including recesses and flats, are to be caulked and hose tested on completion. At watertight flats the side frames if continuous are to be suitably collared, alternatively they may be cut and bracketed or otherwise effectively connected to the flat.

Peak bulkheads not forming boundaries of tanks are to be tested by filling the peaks with water to the level of the load waterline.

### Passenger Ships

**1627** In passenger ships, the number and construction of the watertight bulkheads and watertight doors will be specially considered. Each watertight door shall be tested by water pressure to a head up to the bulkhead deck. The test may be carried out either before or after the door is fitted. (*See* F 801 and F 805).

### Cross-references

**1628** For deep tanks, peak tanks and oil fuel bunkers, *see* D 19 and D 20.

For watertight tunnels, *see* D 17.

For machinery casings in 'tween decks, *see* D 2214.

## Section 17

### WATERTIGHT TUNNELS

### Tunnels

**1701** Where machinery is amidships the shafting is to be enclosed in a watertight tunnel large enough to permit of proper examination and repair of the shafting. A watertight door is to be provided at the forward end of the tunnel. Pipe tunnels are to have dimensions adequate for reasonable access.

### Plating

**1702** The thickness of plating on flat sides and curved tops of tunnels is to be determined from Table 37 and associated notes.

If the top of the tunnel is flat the plating is to be as required by D 1618 for horizontal flats of watertight bulkheads.

**1703** Under hatchways the top plating is to be increased by 2,5 mm., unless covered with wood not less than 50 mm. in thickness which is to be secured without through fastenings in the plating.

### Stiffeners and End Attachments

**1704** The scantlings of stiffeners are to be determined from Table 38 and associated notes.

For flat tunnel tops the scantlings of stiffeners are not to be less than required by D 1618 for flats of watertight bulkheads.

The stiffeners are to overlap and be connected to the tunnel base angle. Angle stiffeners 150 mm. in depth and all bulb angle stiffeners are to be attached to the inner bottom by lugs riveted as required by Table 36. Where welded construction is adopted equivalent arrangements are to be made.

### Boundary Angles

**1705** The thickness of all boundary angles is to be 2,5 mm. greater than the Table thickness of curved top plating given in Table 37.

### Recesses

**1706** The scantlings of plating and stiffeners for thrust and other recesses are to be determined as required by D 1617 and D 1618 for watertight bulkheads.

### Tunnels in Deep Tanks

**1707** When tunnels and recesses form boundaries of deep tanks the requirements of D 19 or D 20 are also to be complied with.

### Local Strengthening

**1708** Additional strengthening is to be fitted under the heels of pillars, hatch end supports or masts stepped on the tunnel. The strength of bulkheads in way of watertight doors is to be maintained as required by D 1612.

### Ventilators

**1709** Tunnel ventilators are to have scantlings suitable for the pressure to which they may be subjected and are to be made watertight.

**Riveting, Caulking and Testing**

**1710** Riveting and caulking are to be as required by D 1621 and D 1626 for watertight bulkheads.

Tunnels are to be hose tested on completion.

## Section 18

### NON-WATERTIGHT BULKHEADS

**Centre Line Bulkheads**

**1801** The thickness of bulkhead plating in ships exceeding 45 metres in length is to be 7,5 mm. in holds and 6,5 mm. in 'tween decks.

**1802** Riveted connections of bulkheads to the decks and inner bottom are to be by single angles 9 mm. in thickness, but the attachments to the inner bottom are to be double riveted for two frame spaces at the ends of the hatchways; welded connections are to be of equivalent strength.

**1803** The scantlings of stiffeners are to be determined from Table 39 and associated notes. The stiffeners may be spaced two frame spaces apart provided the frame spacing does not exceed 760 mm.

**1804** Hold stiffeners are to be attached to the inner bottom by double riveted lugs or welded at their lower ends. Stiffeners at the ends of hatchways, both in holds and 'tween decks, are to have flanged brackets at top and bottom, or equivalent arrangements. Deck beams are to be connected to the stiffeners or plating of the bulkhead.

**Coal Bunker Bulkheads**

**1805** The thickness of plating is to be as required by 1801, but the thickness of the lowest strake is to be 9 mm.; this strake is to extend at least 600 mm. above the stokehold platform. Boundary angles are to be 9 mm. in thickness at the top and sides and 10 mm. at the bottom.

**1806** The scantlings of stiffeners of longitudinal bulkheads which support the deck are to be as required by 1803.

**1807** The scantlings of stiffeners of transverse bulkheads and of longitudinal bulkheads not supporting the deck are to be as required by Table 39, note 4.

**1808** At sloping bunker casings the scantlings of stiffeners are to be suitably increased or the stiffeners are to be additionally supported by angle stays from the deck beams.

**Cross-references**

**1809** For non-watertight bulkheads at after end of cross bunkers, *see* D 1601.

For passenger ships, *see* F 801.

## Section 19

### DEEP TANKS AND PEAK TANKS

**Bulkheads**

**1901** The scantlings of plating and stiffeners of boundary bulkheads are to be determined from Tables 32 and 40 respectively, and associated notes. The plating is not to be less in thickness than 7,5 mm. in ships exceeding 45 metres in length. Stiffeners are to have bracketed attachments as required by D 1614.

**1902** Boundary angles are to be 2,5 mm. thicker than the Table thickness of the bulkhead plating to which they are attached.

**1903** The maximum head to which the tank will be subjected is to be shown on the plans submitted for approval.

**1904** For tanks which exceed 9 metres in length the scantlings and arrangements will be specially considered.

**Decks**

**1905** The thickness of plating of a deck forming the crown of a tank is to be 1 mm. greater than that which would be required by Table 32 for plating at the same depth, corrected, if necessary, for spacing, but is to be not less than 8 mm. with beams or longitudinals spaced 610 mm. apart and 10 mm. where the spacing is 915 mm., with proportionate thickness for intermediate spacing; the plating is also to satisfy the requirements of D 11.

**1906** Beams are to be equivalent in strength to the stiffeners of boundary bulkheads, but are also to satisfy the requirements of D 14.

**1907** Beams in deep tanks are to be supported by quarter girders, the scantlings of which are to be determined from Table 41 and associated notes but are not to be less than would be required by D 15.

**1908** Pillars supporting the deck girders are to satisfy the requirements of D 1516 to D 1524.

**Side Frames**

**1909** The modulus of side frames in deep tanks is to be increased by 15 per cent beyond the requirements of D 6.

Where the frame spacing exceeds the frame spacing in Table 12 by 75 mm. or more, special consideration will be given to this framing.

**Tunnels and Recesses**

**1910** The scantlings and arrangements of tunnels, horizontal and longitudinal steps, and recesses generally, are to be equivalent to the requirements for boundary bulkheads.

**Centre Line Bulkheads**

**1911** Where a complete centre line division is fitted in deep tanks the arrangements are to be as required by D 2016 and D 2017.

**Ventilators**

**1912** Ventilators from deep tanks passing through a 'tween deck are to be strong enough to withstand the pressure to which they may be subjected and they are to be made watertight.

**Riveted Connections**

**1913** Riveted connections are to be in accordance with the requirements of Table 52 H.

**Testing**

**1914** Tanks are to be tested by a head of water equal to the maximum to which the tank may be subjected, but not less than 2,5 metres above the crown of the tanks where the depth D (as defined in D 203) exceeds 5 metres, reduced to 1 metre where D is 3 metres or less.

**General**

**1915** When boundary bulkheads of tanks form part of the watertight subdivision of the ship the requirements of D 16 are also to be satisfied.

**1916** Tanks intended to carry oil fuel or liquid cargoes are to comply with the requirements of D 20 or D 21.

**1917** Where an approved system of corrosion control is fitted in the topside tanks or side ballast tanks, the thickness of the plating and stiffeners of the transverse bulkheads in the tanks, the wash plates, vertical webs, deck and side transverses, longitudinal bulkhead webs and stiffeners, cross ties, and horizontal girders may be reduced by 10 per cent.

The plating of the longitudinal bulkhead and the sloping sides of the topside tanks or other items where protected on one side only, may be reduced by 5 per cent.

**Cross-references**

**1918** For air and sounding pipes, *see* D 24.

For pumping and piping arrangements, *see* Chapter E.

## Section 20

## DEEP TANKS AND DOUBLE BOTTOM TANKS CARRYING OIL FUEL FOR SHIP'S USE

**Flash Point**

**2001** The following requirements apply to the construction of compartments for the carriage, for ship's use, of oil fuel the close test flash point of which, as determined by a standard type of flash point apparatus, is above 65,5° C.

**2002** When the requirements of the Rules have been complied with a notation will be made in the Register Book, except for motorships, as follows: OF (with date).

**Boundary Bulkheads**

**2003** The thickness of plating is to be determined from Table 32 and associated notes; the plating is not to be less than 7,5 mm. in thickness in ships exceeding 45 metres in length.

**2004** The scantlings of stiffeners are to be determined from Table 40 and associated notes. The ends of the stiffeners are to be attached by brackets in accordance with D 1614. The stiffeners are to be supported, if necessary, by horizontal girders as required by 2006 to 2009.

**2005** For tanks which exceed 9 metres in length the scantlings and arrangements will be specially considered.

**Horizontal Girders**

**2006** Bulkhead stiffeners and side frames may be supported by horizontal girders having scantlings determined from Table 41 and associated notes.

**2007** If girders are fitted, they are to form a continuous line of support on bulkheads and ship's side. They are to be connected at their ends by flanged brackets, having the same thickness as the web plate of the thicker girder and a length of arm, measured from the point of the bracket to the edge of the girder, equal to the width of the wider girder. If the bracket terminates on a bulkhead the length of the arms is to be equal to the width of the girder. All girders and brackets are to be double riveted or to have equivalent welded connections and the ends of the brackets are to be adequately supported.

**2008** Riveted connections of girder plates to the bulkheads or shell plating are to be double for about twice the width of the girder at each end and may be single elsewhere.

**2009** The girders are to be supported by tripping brackets at the toes of the end brackets and elsewhere at every third stiffener or frame. Stiffeners or frames intermediate between these brackets are to be effectively connected to the girders.

**2010** For tanks which exceed 9 metres in length the scantlings and arrangements will be specially considered.

**Side Frames**

**2011** The modulus of the side frames is to be increased by 15 per cent beyond the requirements of D 6 unless horizontal side girders are fitted.

**2012** If horizontal side girders are fitted the scantlings of the frames are to be determined as required by D 6, modified as given below, and the scantlings of the frame for the full depth of the tank are to be the maximum of the section modulii derived by the following three methods:—

1. h measured to lowest horizontal girder (minimum value 2,5 metres) and the resulting modulus increased by 15 per cent.
2. h measured from a single girder to the deck forming the crown of the tank or between girders when two or more girders are fitted.
3. h measured from uppermost girder (when two or more girders are fitted) to the deck forming the crown of the tank and the resulting modulus reduced by 15 per cent.

**Decks**

**2013** The scantlings of decks forming the crowns of oil fuel tanks are to comply with the requirements for deep tanks given in D 1905 to D 1908.

**2014** Where a steel deck abuts on an oil bunker bulkhead the deck plating is to be attached to the bulkhead either by double angles, single riveted, by a T bar, or by an equivalent welded connection. If the deck acts as a girder supporting the bulkhead stiffeners the panel of deck plating adjoining the bulkhead may require to be stiffened for this purpose.

**Tunnels and Recesses**

**2015** The scantlings and arrangements of tunnels, horizontal and longitudinal steps, and recesses generally, are to be equivalent to the requirements for boundary bulkheads.

**Centre Line Bulkheads**

**2016** Deep tanks which extend from side to side of the ship are to have a centre line bulkhead and quarter girders.

**2017** Centre line bulkheads may be intact or perforated as desired. If intact, the scantlings and arrangements are to be as required for boundary bulkheads by 2003 to 2005.

If perforated, the modulus of the stiffeners may be 50 per cent of that required for boundary bulkheads by D 19, using H measured to the crown of the tank. The stiffeners are to be bracketed at top and bottom. The area of perforations is to be not less than 5 per cent nor more than 10 per cent of the total area of the bulkhead.

When brackets from horizontal girders on the boundary bulkheads abut on the centre line bulkhead a light intercostal stringer is to be fitted at that level for the full length of the tank, or equivalent arrangements are to be provided.

**Ventilators**

**2018** Ventilators from deep tanks, passing through a 'tween deck, are to be strong enough to withstand the pressure to which they may be subjected and they are to be made oiltight.

**Watertight Subdivision**

**2019** When the bulkheads of oil fuel bunkers form part of the watertight subdivision of the ship, they are also to comply with the requirements of D 16.

**Double Bottom Tanks**

**2020** Holes are not to be cut in the centre girder except in the forward and after tanks, and elsewhere where tanks are narrow due to subdivision. The centre girder need not be caulked or tested.

**2021** The inner bottom plating in cargo holds where there is no ceiling is to be not less in thickness than 8,5 mm. when the spacing of frames or longitudinals is 610 mm., and 10 mm. when the spacing is 760 mm., with proportionate thicknesses for intermediate spacing.

Seams and end laps of inner bottom plating in the engine and boiler spaces, and in the holds where ceiling is not fitted over the whole inner bottom, are to be at least double riveted.

**Special Requirements for Refrigerated Ships**

**2022** Where the hold above a double bottom tank carrying oil fuel is used for refrigerated cargo the tank side brackets and floor plates are to be attached to the margin plate by T bars, or by welding, and gussets are to be welded to the margin plate. The connections of hold pillars, including heel doubling plates, also of the floors and intercostal plates under the pillars to the inner bottom, are to be welded. The attachments of manhole covers are not to pass through the inner bottom plating.

**2023** For the requirements for protection of oiltight bulkheads, decks and inner bottom in way of refrigerated holds, *see* E 345 and E 346.

**Protection and Drainage**

**2024** Compartments carrying oil are to be separated by cofferdams from those carrying fresh water; oil fuel

compartments are to be similarly separated from those carrying vegetable oil. Cofferdams are to be suitably ventilated.

**2025** Sparring or lining is to be fitted on the bulkheads in holds to prevent leakage of oil coming into contact with the cargo. Gutterways are to be arranged at the foot of these bulkheads to ensure that leakage shall have free drainage to the wells or limbers. Gutterways are also to be fitted in boiler spaces.

**2026** Where a bulkhead including its boundary connections is wholly welded, the requirements of 2025 may be dispensed with, except that a gutterway is to be fitted in the boiler room.

**2027** Ceiling on the inner bottom, if fitted, is to be laid on battens not less than 12 mm. in thickness. Battens are to be so laid as to permit the drainage of oil to the bilges or wells.

**2028** Drip trays or gutterways with suitable draining arrangements are to be provided for all tanks which do not form part of the hull structure, at pumps, valves and elsewhere where there is a possibility of leakage. Drip trays are also to be fitted under oiltight decks, except if these are completely welded, when the drip trays need only be fitted over the boilers.

**2029** If cargo or coal is carried in a compartment adjacent to an oil fuel settling tank which may be heated, the compartment side of the bulkhead or deck is to be insulated.

**Riveted Connections**

**2030** Riveted connections are to be in accordance with the requirements of Table 52 H.

**Testing**

**2031** All oil tanks are to be tested by a head of water equal to the maximum to which the tank may be subjected but not less than 2,5 metres above the crown of the tank where the depth D (as defined in D 203) exceeds 5 metres, reduced to 1 metre where D is 3 metres or less. The attachment of fittings to oiltight surfaces should be completed before the tanks are tested.

**Workmanship**

**2032** The workmanship throughout is to be of the highest character and is to be submitted to close inspection. (*See* D 31 and D 32.)

**Cross-reference**

**2033** For air and sounding pipes and the arrangements and requirements for the use of oil fuel, *see* Chapter E.

## Section 21

### DEEP TANKS AND PEAK TANKS CARRYING OIL AS CARGO

**Oil Fuel**

**2101** Oil fuel having a flash point above 65,5° C. may be carried as cargo in deep tanks or peak tanks providing the scantlings and arrangements of the tanks are in accordance with the requirements of D 20 for oil fuel bunkers, except that the riveting may be as required for deep tanks by Table 52 H and the centre line bulkhead need not be fitted; if, however, the tanks are intended to be partially filled only, the requirements of D 20 are to be complied with in all respects.

**2102** When these requirements have been carried out a notation will be made in the Register Book as follows: "Deep tanks and (or) peak tanks—oil F.P. above 150° F."

**Vegetable and Similar Oils**

**2103** Vegetable oil, or similar oils, may be carried in deep or peak tanks constructed in accordance with the requirements of D 19 for ballast tanks, with the addition of a centre line bulkhead as required by D 2016 and D 2017, provided that the ventilation, drainage and control generally are as required for oil fuel bunkers.

**2104** Tanks are to be designed and constructed with a view to their being cleaned with reasonable facility.

**2105** Deep or peak tanks carrying vegetable or similar oils are to be separated from those carrying oil fuel or fresh water by a cofferdam.

**2106** When these requirements have been complied with a notation will be made in the Register Book as follows: "Deep tanks and (or) peak tanks—vegetable oil."

**2107** Vegetable oil may also be carried in tanks complying with the requirements of 2101 and if desired the notation may be as follows: "Deep tanks and (or) peak tanks—oil F.P. above 150° F. or vegetable oil."

**2108** Where tanks are intended for other liquid cargoes of a special nature the scantlings and arrangements will be considered in relation to the density and nature of the cargo and an appropriate notation will be made in the Register Book.

**Loading Certificates**

**2109** When a loading certificate is requested, before a cargo of oil is loaded the tank should be tested under pressure and examined for cleanness to ensure that it is in a proper condition to receive the oil cargo.

In special circumstances the Committee will be prepared, with the consent of all interested parties, to consider alternative arrangements in respect of the testing of these tanks.

**Cross-references**

**2110** For protection of oiltight bulkheads and decks in way of refrigerated holds, *see* E 345 and E 346.

## Section 22

### MACHINERY SPACES

**Engine Seatings**

**2201** Built-up engine seatings are to be of ample scantlings and efficiently supported by brackets both longitudinally and transversely. The transverse brackets should be fitted over the floors and, as far as practicable, the longitudinal girders in the bottom are to be under those in the seating.

**2202** If engines are bolted directly to the inner bottom the thickness of the plating under the engines is to be suitably increased.

The plating under the foremost shaft tunnel bearing is also to be increased in thickness and is to be scarphed in to the heavy plating under the engine bedplate.

**2203** In ships having a single bottom in the engine space, the floors are to be increased in depth (*see* D 403) and the engines are to be seated on plating of substantial thickness.

**2204** Additional full depth fore and aft girders are to be fitted under the engines and thrust block seatings. (*See* D 416, D 504 and D 505.)

**2205** If engines are of relatively high power the strength of the structure and attachments of the seating are to be increased, special consideration being given to the power and type of engines and the relation of height of the engines to the width of the bedplate; particulars are to be submitted.

**Boiler Bearers**

**2206** Boiler bearers are to be of substantial construction and efficiently supported by brackets. (*See* D 407 and D 507.)

**Additional Strengthening in Machinery Space**

**2207** Additional transverse strengthening is to be provided by means of web frames and strong beams, with suitable pillaring or other arrangements.

**Clearance between Bulkheads and Boiler**

**2208** Bunker and hold bulkheads are to be kept well clear of boilers and uptakes, and sufficient space is to be allowed all round boilers for proper access.

**2209** Decks, or the tops of recesses, are to be not less than 1,25 metres clear of the top of the boiler. Uptakes and flat surfaces of boilers are to be not less than 460 mm., and the cylindrical shells of boilers not less than 230 mm., from coal bunker and hold bulkheads.

**Protection of Decks under Donkey Boilers**

**2210** Decks under donkey boilers are to be increased 2,5 mm. in thickness and protected under coal-fired boilers by not less than 50 mm. of firebrick or cement. These requirements are to extend to any part of the deck on to which fires from the donkey boiler may be drawn.

**Exposed Casings Protecting Machinery Openings**

**2211** Engine and boiler openings on weather decks are to be protected by casings of adequate height having scantlings determined from Table 23 and associated notes. The tops of casings are to be suitably plated and stiffened.

**2212** The deck openings should not be larger than necessary and suitable cross tie arrangements are to be provided.

**2213** On the uppermost continuous deck of ships in which the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck, and on raised quarter decks, the doors in exposed casings are to be of steel. All doors are to be strongly constructed and capable of being closed and secured from both sides.

The sills of exposed doorways on the uppermost continuous deck, where the draught is as defined above, are to be 610 mm. in height above the upper surface of the deck; the sills of exposed doorways on raised quarter decks are to be 457 mm. and those on other superstructure decks including those extending for the full length of the ship 380 mm. in height.

**Protected Casings**

**2214** The plating is to be not less than 6,5 mm. in cargo spaces and 5 mm. in accommodation spaces in superstructures; stiffeners are to be $75 \times 65 \times 6,5$ mm. angles spaced 760 mm. apart. Where trunked casings form boundaries of coal bunkers they are to comply with the requirements of D 1805 to D 1808.

**Skylights and Gratings**

**2215** Engine room skylights are to be substantially constructed and are to be securely connected to the coamings. Gratings over stokehold openings are to be protected by hinged plate covers, which are to be watertight if the level of the openings is less than 610 mm. above the top of the hatch coamings required by D 2301. (*See* also F 336.)

**Means of Escape**

**2216** Two means of escape, one of which may be a watertight door, shall be provided from each engine room, shaft tunnel and boiler room. Where no watertight door is available, the two means of escape shall be formed by two sets of steel ladders as widely separated as possible leading to doors in the casing similarly separated and from which access is provided to the lifeboat embarkation deck. In the case of ships less than 2000 tons gross tonnage, this requirement may be dispensed with, due regard being paid to the width and disposition of the casing.

**Communications**

**2217** Two means of communication are to be fitted between the bridge and the engine room. One means shall be an engine room telegraph.

**Aluminium Alloy**

**2218** When aluminium alloy is used in the construction of the boundaries of the machinery space or in the casings or pillars, suitable insulation is to be fitted so that the structure remains effective in the presence of intense heat. The extent of the insulation is to be governed by the fire risk on either side of the boundary.

**Cross-references**

**2219** For scantlings of single bottoms in machinery space, *see* D 417.

For scantlings of double bottoms in machinery space, *see* D 533 and D 534.

For frames in boiler room, *see* D 614.

For passenger ships, *see* F 807, F 812 and F 814.

## Section 23

### HATCHWAYS AND DECK OPENINGS

**Height of Coamings**

**2301** The minimum height of steel coamings above the upper surface of decks is to be as follows:—

On the weather portions of the uppermost continuous deck where the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck ... ... ... ... ... ... 610 mm.

On the weather portions of superstructure decks, including superstructures extending for the full length of the ship, for the forward 0,25L ... ... 610 mm.
for the remainder and on raised quarter decks 457 mm.

On decks inside superstructures where the openings in the end bulkheads have no means of closing... 457 mm.

On decks inside superstructures where the openings in the end bulkheads are closed by strong hinged wood doors, wood shifting boards fitted in channels or portable plates secured by hook bolts ... ... ... ... 229 mm.

**2302** Hatchways on other decks and in positions not detailed in 2301 are to be suitably framed.

**Construction of Coamings**

**2303** At hatchways exposed to the weather the thickness of the side and end coaming plates is to be 11 mm. where the length L is 61 metres or greater and 9 mm. where L does not exceed 30 metres, with intermediate values obtained by interpolation. Coamings are to be stiffened on their upper edges by a substantial moulding. At hatchways below the uppermost continuous deck or within an intact superstructure the coamings are to be not less than 10 mm. in thickness.

**2304** Angles connecting the coamings to the deck and the corner angles connecting the side and end coamings are to be of the same thickness as the coaming plates. Coaming angles are to extend 10 mm. above the wood deck.

**2305** Side coamings of all hatchways are to extend at least to the lower edge of the beams, which are to be attached to the coamings as required by Table 52 H.

For welded construction, *see* D 3108.

**2306** Hatchway side and end coamings which are 610 mm. or more in height are to be stiffened by a horizontal bulb angle, or equivalent, fitted near the upper edge of the coaming; in ships 76 metres or more in length the bulb angles are to be not less than 180 mm. in depth. Additional support is to be afforded by fitting brackets or stays from the bulb angle to the deck at intervals of not more than 3 metres.

**2307** The scantlings and arrangements of coamings more than 915 mm. in height and of coamings acting as girders will be specially considered. (*See* D 1404 and D 1509 to D 1513.)

**2308** Coamings are to be made watertight above the deck and coaming angles are to be suitably turned or the coamings welded.

**2309** Extension brackets or rails arranged approximately in line with the hatch side coamings and intended for stowage of steel covers are not to be welded to a deckhouse, masthouse, or to each other, unless they form part of the longitudinal strength members.

### Hatchway Beams and Carriers

**2310** Scantlings of hatchway beams are to be determined from Table 43 and associated notes.

**2311** Web plate beams are to be stiffened at their upper and lower edges by double angles or welded face plates, but when bulb plates are fitted this stiffening is required at the upper edge only. The upper angles or face plates are to extend to the extreme ends of the beams.

**2312** The ends of the web plates are to be flushed up on each side by doubling plates of the same thickness as the mounting angles and at least 180 mm. wide. In welded hatchway beams, equivalent arrangements for stiffening the ends of the web plates are to be adopted.

**2313** At beams which carry the ends of wood hatch covers the web plate is to extend well above the top of the upper angles or face plate of the hatch beams. The bearing surface for hatch covers is to be not less than 65 mm. (*See* 2320.)

**2314** Hatchway beams are to be supported at their ends by carriers, sockets or other suitable arrangements, having a minimum bearing surface of 75 mm. Carriers formed of angles are to be not less than 12,5 mm. thick and one angle is to be extended down to the level of the deck. If the carriers are of a form which will not permit of extension to the deck level the coaming plate is to be increased in thickness by 12½ per cent, or equivalent strengthening provided.

**2315** The bottoms of all carriers are to be of solid construction.

**2316** Sliding hatchway beams are to be provided with an efficient device for locking them when in their correct fore and aft positions.

### Hatch Covers

**2317** Hatch covers are to be fitted to the hatchways of all decks, except that at hatchways on decks as defined in 2302 the hatch covers may be dispensed with if desired by the Owners and specially approved by the Committee when a suitable notation will be entered in the Register Book.

**2318** The finished thickness of wood hatch covers at hatchways on weather decks, and in 'tween decks of normal height, is to be 60 mm. for an unsupported span of 1,52 metres, and 83 mm. for 1,98 metres; the thicknesses for intermediate spans are to be in proportion.

When the 'tween deck height in cargo spaces exceeds 2,6 metres the thickness of the covers is to be increased at the rate of 5 per cent per 0,3 metre excess in 'tween deck height.

**2319** The ends of all wood hatch covers are to be protected by encircling galvanised steel bands, about 65 mm. wide and 3 mm. thick, efficiently secured.

**2320** Hatch rests are to be of the same thickness as the mounting angles given in Table 43 A & B and are to provide at least 65 mm. bearing surface for the hatch covers; they are to be bevelled if required to suit the slope of the hatches.

### Tarpaulins and Securing Arrangements

**2321** Tarpaulins in good condition are to be provided for all hatchways requiring coamings 229 mm. or more in height; not less than two tarpaulins are to be provided for all hatchways in exposed positions.

**2322** Tarpaulins are to be free from jute, thoroughly waterproofed and of ample strength. The minimum weight of the material before treatment is to be 0,65 kg. per square metre if the material is to be tarred, 0,60 kg. if to be chemically dressed or 0,55 kg. if to be dressed with black oil.

A certificate to the above effect is to be supplied by the makers of the tarpaulins.

**2323** Cleats are to be fitted at all hatchways requiring tarpaulins, spaced not more than 610 mm. from centre to centre, the end cleats being arranged not more than 150 mm. from the hatchway corners. Cleats are to be of an approved pattern at least 65 mm. wide, with edges so rounded as to minimise the cutting of the wedges. The thickness should be not less than 10 mm. for angle cleats and 11 mm. for smithed cleats which should be stiffened by pressing out the centre to form a web extending to the bottom of the palm. Drop forgings should be of equivalent strength. Cleats should be so set as to fit the taper of the wedges.

**2324** Battens and wedges are to be efficient and in good condition. Wedges are to be of tough wood, generally not less than 200 mm. in length and 50 mm. in width. They should be cut on a standard taper of one in six and should be not less than 15 mm. in thickness at the point.

**2325** Where coamings are required to be 610 mm. in height, steel bars or other equivalent means are to be provided for efficiently and independently securing each

section of hatchway covers after the tarpaulins are battened down. Where hatchway covers extend over intermediate supports, steel bars or their equivalent are to be fitted at each end of each section of covers. At all other hatchways in exposed positions on weather decks, ring bolts or other fittings for lashings are to be provided.

**Steel Hatch Covers**

**2326** When steel hatch covers are adopted plans and particulars of the scantlings and arrangements are to be submitted.

Built steel covers are to be suitably framed to provide sufficient strength and rigidity, and the scantlings are to be determined from the formulæ given in Table 43, note 6.

Securing cleats and cross joint wedges, together with suitable jointing material, are to be fitted to secure the tightness of the covers on hatchways for which the rule height of coamings required by 2301 is 229 mm. or more. The spacing of securing cleats is not to exceed 990 mm. where rule height of coamings is 610 mm. and 1,07 metres where the rule height of coamings is 457 mm. or 229 mm. The maximum spacing of cross joint wedges is not to exceed 1,22 metres. Suitable securing arrangements are to be fitted on other hatchways.

Steel pontoon hatch covers, that is steel covers having top and end plating with interior webs and frames, extending for the full width of the hatchway and about one quarter of the length, and not fitted with direct securing arrangements, are generally to be in accordance with the requirements of Table 43 Note 6. Where this type of cover is fitted at weather deck cargo hatchways within the forward 0,25L the strength and inertia of the covers is to be at least 20 per cent above the formulæ given in Table 43 Note 6 Type A and the thickness of plating is to be at least 30 per cent above the thickness given by the same note.

Steel hatch covers with special sealing arrangements, or insulated covers, or steel hatch covers to which the requirements of 2321 to 2325 might wholly or in part be applied, will be specially considered.

**Bunker, Access and Trimming Hatchways**

**2327** The construction and the closing and securing arrangements of bunker, access and trimming hatchways are to comply with the requirements of 2301 to 2326 so far as applicable.

**Flush Bunker Scuttles**

**2328** Flush bunker scuttles may be fitted on superstructure decks, including raised quarter decks.

**2329** The scuttles are to be substantially constructed with screw or bayonet joints. If the scuttles are not hinged the covers are to be permanently attached by a chain.

**Trunked Hatchways**

**2330** When hatchways are trunked through one or more 'tween decks, and hatchway beams and covers are dispensed with at the intermediate decks, the hatchway beams, coamings and covers immediately below the trunk are to be adequately strengthened; plans are to be submitted for approval.

**Means of Escape**

**2331** In and from all crew and passenger spaces and spaces in which crew are normally employed, other than machinery spaces, stairways and ladders are to be arranged so as to provide ready means of escape to the lifeboat embarkation deck. (For means of escape from machinery spaces, *see* D 2216).

**Companionways**

**2332** Companions on exposed decks are to be of steel effectively secured to the deck. The height of the doorway sill is to be as required for hatchway coamings in the same position.

**2333** Within the forward 0,25L the doors are to be of steel and elsewhere may be of hard wood not less than 50 mm. in thickness. The doors are to be capable of being operated and secured from both sides.

## Section 24

### VENTILATORS, AIR PIPES AND SOUNDING PIPES

**Ventilation, General**

**2401** Where mechanical ventilation is adopted plans showing the construction of the weather deck fittings are to be submitted for approval.

**Ventilator Coamings**

**2402** The minimum height of ventilator coamings above the upper surface of decks exposed to the weather is to be as follows:—

On the uppermost continuous deck where the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck ... 915 mm.

On superstructure decks, including superstructures extending for the full length of the ship,
for the forward 0,25L ... ... ... ... 915 mm.
for the remainder and on raised quarter decks 760 mm.

Ventilator coamings of a greater height than 915 mm. are to be specially supported and secured.

**2403** The scantlings of the coamings and their attachment, if riveted to the deck plating, are to be in accordance with the following Table:—

| Internal diameter of ventilator coamings | | Coaming plate | Deck angle | Rivets at 4 dia. spacing centre to centre |
|---|---|---|---|---|
| Above | Not exceeding | | | |
| Millimetres | | Millimetres | Millimetres | Dia. Millimetres |
| — | 200 | 7,5 | 75×75×8,5 | 19 |
| 200 | 280 | 8 | 75×75×9 | 19 |
| 280 | 330 | 8,5 | 90×90×9,5 | 19 |
| 330 | 380 | 9 | 90×90×10 | 19 |
| 380 | 430 | 9,5 | 90×90×10,5 | 22 |
| 430 | | 10 | 90×90×11 | 22 |

**2404** When the deck is sheathed with wood the vertical flange of the coaming angles is to extend 10 mm. above the wood sheathing.

**2405** The deck plating in way of ventilator coamings is to be efficiently stiffened between the beams or longitudinals.

### Covers

**2406** All ventilator coamings are to be provided with strong plugs and canvas covers, or equally efficient appliances, for closing the openings when the cowls are unshipped.

### Minor Ventilators

**2407** Mushroom and gooseneck ventilators are to be strongly constructed and efficiently secured to the deck plating.

### Air and Sounding Pipes

**2408** Air and sounding pipes are to be fitted in accordance with the requirements of Chapter E.

**2409** The height of air pipes, from upper surface of deck to opening, on decks exposed to the weather is to be as follows:—

On the uppermost continuous deck where the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck ... 915 mm.
On raised quarter decks ... ... ... 760 mm.
On superstructure decks other than raised quarter decks but including those extending for the full length of the ship ... ... ... ... ... 457 mm.

**2410** Openings of air and sounding pipes are to be provided with satisfactory arrangements to prevent the free entry of water.

**2411** Striking plates of sufficient thickness, or their equivalent, are to be fitted under all sounding pipes.

**2412** In all cargo spaces or coal bunkers, air and sounding pipes are to be well protected and in coal bunkers the protection is to be of steel.

### Cross-references

**2413** For passenger ships, *see* F 815 to F 817.
For cargo ships, *see* F 1004.

## Section 25

## BULWARKS, FREEING PORTS, SCUPPERS, SANITARY DISCHARGES AND SIDE SCUTTLES

### Bulwarks

**2501** Plate bulwarks are to be stiffened by a strong rail section and supported by stays from the deck, spaced not more than 1,85 metres apart. Where bulwarks are cut to form a gangway or other opening, stays of increased strength are to be fitted at the ends of the openings. The plating in way of mooring pipes is to be doubled or increased in thickness.

**2502** The arrangements for continuity of strength at the ends of superstructures are to be as required by D 1206. Bulwarks should not be cut for gangway or other openings near the breaks of superstructures.

**2503** In welded ships, the bulwarks should be arranged to ensure their freedom from main structural stresses. (*See* D 3109.)

**2504** The bulwarks of ships carrying timber deck cargoes are to be not less than 990 mm. in height and are to be additionally stiffened at the upper edge; bulwark stays are to be attached to the deck in way of beams.

### Freeing Ports

**2505** Where weather decks are enclosed by bulwarks ample provision is to be made for rapidly freeing the decks from large quantities of water by means of freeing ports.

**2506** The area of freeing port openings at uppermost continuous decks where the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck, and at raised quarter decks, is to be as follows:—

| Length of well | Area on each side | Length of well | Area on each side |
|---|---|---|---|
| Metres | Square Metres | Metres | Square Metres |
| 4,5 | 0,741 | 16,5 | 1,109 |
| 6,5 | 0,801 | 18,5 | 1,168 |
| 8,5 | 0,863 | 20,5 | 1,250 |
| 10,5 | 0,925 | 22,5 | 1,373 |
| 12,5 | 0,985 | 24,5 | 1,495 |
| 14,5 | 1,046 | 26,5 | 1,618 |

On superstructures, other than raised quarter decks, but including those extending for the full length of the ship, the area of the openings is to be half the area given in the preceding Table.

In ships having deficient sheer or where there is no free passage for water across the weather deck, the freeing port area is to be suitably increased or open rails are to be fitted.

Provision is also to be made for freeing water from all open or partially open spaces in which water may be shipped and contained.

**2507** The lower edges of freeing ports are to be as near to the deck as practicable and the openings are to be protected by rails spaced not more than 230 mm. apart. If hinged doors are fitted over the openings their hinges are to have brass pins; fittings for keeping the doors closed are not to be provided.

### Scuppers

**2508** Scuppers sufficient in number and size to provide effective drainage are to be fitted in all decks.

**2509** When the weather deck stringer angle is cut in way of scuppers compensation is to be provided.

**2510** Scupper pipes which drain spaces below the freeboard deck are to be led to the bilges, or may be led overboard provided the spaces drained are above the load waterline and the scuppers are fitted with screw-down non-return valves capable of being operated from a position always accessible and above the freeboard deck. Means are to be provided for showing whether the valves are open or closed.

**2511** Scuppers draining spaces in intact superstructures or in superstructures having the openings in the end bulkheads closed by strong hinged steel doors may be led to the bilges or may be led overboard and fitted if considered necessary with screw-down, non-return valves as required by 2510.

**2512** Scuppers draining spaces in short superstructures having the openings in the end bulkheads closed by appliances as described in D 2301 are to be led overboard, with the exception of the scuppers above the machinery space which may be led to the bilges where the lower ends of the pipes are to be visible and readily accessible.

**2513** Scuppers which drain overboard from spaces referred to in 2511 and 2512 and which are not required to have storm valves with positive means of control are to be fitted with non-return valves of automatic type.

**2514** Scuppers draining spaces in long superstructures having the openings in the end bulkheads closed by appliances as described in D 2301 are, within the range of the machinery space, to be led to the bilges where the lower ends of the pipes are to be visible and readily accessible.

Where additional scuppers are required to ensure effective drainage of the spaces clear of the machinery space these scuppers are to be led to the hold bilges and fitted with screw-down valves at the freeboard deck, the valves being controlled from a position which is accessible at all times above the freeboard or superstructure deck. Means are to be provided for showing whether the valves are open or closed.

**2515** Plans showing the arrangement of scuppers for draining refrigerated cargo compartments are to be submitted for consideration.

### Sanitary Discharges

**2516** Sanitary discharges from spaces below the freeboard deck are to be provided with efficient and accessible means of preventing water from passing inboard.

Each discharge is to have a screw-down, automatic, non-return valve operated from an accessible position above the freeboard deck. Means are to be provided for showing whether the valve is opened or closed.

Alternatively, two automatic non-return valves, without positive means of closing, may be fitted provided the upper valve is in a position which is always accessible for examination.

**2517** Discharges from spaces within enclosed superstructures are each to be fitted with automatic non-return valves, but arrangements similar to those described in 2516 may be required.

**Materials for Valves and Pipes**

**2518** Castings enclosing non-return valves are to be of substantial construction. These castings, also the elbow pieces where no valves are required, are to be of approved material other than ordinary cast iron. The length of pipe attached to the valve or elbow piece is to be of galvanised steel of standard steam pipe quality. (*See also* F 706).

**Protection of Pipes and Valves**

**2519** In all cargo spaces or coal bunkers, scupper pipes, discharges and screw-down valves and their controls are to be well protected; in coal bunkers the protection is to be of steel.

**Side Scuttles**

**2520** Side scuttles and deadlights are to be of approved design and are to be made of approved material other than ordinary cast iron.

Side scuttles to spaces below the freeboard deck or to spaces within enclosed superstructures are to be fitted with efficient inside deadlights permanently attached and capable of being closed watertight.

In enclosed superstructures permanently allocated to passengers or crew portable deadlights may be provided if stowed adjacent to the scuttles, provided they are accessible at all times in service.

**2521** In passenger ships, the position and construction of the side scuttles will be specially considered. (*See also* F 813.)

## Section 26

### RUDDERS

**Materials**

**2601** Steel castings are to comply with the requirements of P 5.

**2602** Forgings made of ingot steel are to comply with the requirements of P 6.

**2603** If forgings are made from scrap material, either iron or steel scrap may be used, but a mixture of iron and steel is not permitted.

**Diameter of Rudder Head and Mainpiece**

**2604** The diameter of the rudder head is to be determined from Table 44 and associated notes and is also to be designed in relation to the maximum astern speed.

**2605** The mainpiece of rudders with cast or forged frames is to be of the same diameter at the top pintle as the rudder head and is to taper evenly to the heel, where the diameter is not to be less than 75 per cent of that of the head.

**2606** If the supports of the rudder are so arranged that considerable bending stresses may occur in the mainpiece and head these are to be suitably strengthened.

**Single Plate Rudders**

**2607** The thickness of plates and scantlings of arms of single plate rudders are to be determined from Table 45 and associated notes.

**2608** Arms are to be arranged on alternate sides of the plate and are to be shrunk on to the mainpiece and keyed. In way of each arm the mainpiece is to be increased in diameter by 10 per cent; this increased diameter is to extend above and below the arm for a distance equal to the increase in diameter and beyond these points is to be gradually reduced to the normal diameter of the mainpiece over a distance of one-fifth of the diameter.

**2609** The thickness of the key is to be 10 per cent of the normal diameter of the mainpiece at each arm, and the width is to be twice the thickness.

**Double Plate Rudders**

**2610** The scantlings of cast or forged frames of double plate rudders will be determined in relation to their design. The thickness of the plates is to be derived from Table 46 and associated notes.

**2611** The scantlings of rudders with plate frames will depend upon the arrangements adopted. The thicknesses of the outside plates and of the horizontal and vertical web plates are to be determined from Table 46 and associated notes. Special attention is to be given to the attachment of the pintles and rudder coupling to the body of the rudder.

**2612** Horizontal and vertical webs are not to be attached to side plates by tongue welds. Slot welds are only to be used in association with flat bars on the edges of the webs.

**2613** The internal surfaces of double plate rudders are to be efficiently coated and means for draining the rudder are to be provided.

**Pintles**

**2614** The scantlings of the pintles are to be determined from Table 47 and associated notes.

**2615** The distance between the top pintle and the bearing of the rudder stock should be as short as possible; where the ratio of the unsupported length to the diameter of stock is excessive the diameter of the stock may require to be increased or the length reduced by fitting an additional and accessible bearing.

**2616** Where liners to pintles are fitted they are to be shrunk on to the pintles or otherwise efficiently secured.

### Couplings

**2617** The scantlings of couplings are to be determined from Table 48 and associated notes.

**2618** The bolts are to be fitted and suitable arrangements are to be made to lock the nuts.

### Riveting

**2619** The diameters of rivets in rudder arms are given in Tables 45 and 46.

The rivets are to be spaced 4½ diameters apart and the holes are to be countersunk. Where the breadth of the arm exceeds 115 mm. the riveting is to be reeled and if the breadth exceeds 180 mm. two complete rows of rivets are to be fitted, but, except at the outer ends of the arms, the rivets are not to be directly opposite to each other.

### General

**2620** Suitable arrangements are to be provided to prevent the rudder from lifting.

**2621** When the weight of the rudder is supported by a carrier bearing attached to the rudder head the structure in way is to be adequately strengthened for that purpose. The plating under all rudder head bearings or rudder carriers is to be increased in thickness or doubled.

### Cross-reference

**2622** For strengthening for navigation in ice, *see* D 1006, D 1014 and D 1022.

## Section 27

### STEERING GEAR

### General

**2701** All ships are to be provided with two independent means of steering. In passenger ships and in cargo ships of 500 gross tons and above, one of the gears is to be operated by power. All gears are to be fitted and tested under working conditions to the satisfaction of the Surveyors.

**2702** The power operated main steering gear is to be capable of putting the rudder over from 35 degrees on one side to 35 degrees on the other side with the ship running ahead at maximum service speed. The time taken to put the rudder over from 35 degrees on either side to 30 degrees on the other side is not to exceed 28 seconds at maximum service speed. The gear is also to be designed in relation to the maximum astern speed.

**2703** The auxiliary gear is to be of adequate strength and sufficient to steer the ship at navigable speed and is to be capable of being brought speedily into action in an emergency.

**2704** In cargo ships, a power operated auxiliary gear is to be fitted where the Rule diameter of the rudder stock at the tiller, corresponding to a speed of 10 knots, is 254 mm. and above. Where main steering gear power units and their connections are fitted in duplicate and the duplicate units acting together satisfy the requirements of 2702, and each power unit separately satisfies the requirements of 2703, an auxiliary gear will not be required.

**2705** In passenger ships, the auxiliary gear is to be power operated if the Rule diameter of rudder stock at the tiller exceeds 229 mm. Where main steering gear power units and their connections are fitted in duplicate and each power unit separately is capable of satisfying the requirements of 2702, an auxiliary gear will not be required.

**2706** In passenger ships, where the Rule diameter of the rudder stock at the tiller exceeds 229 mm., an alternative steering position remote from the main steering position is to be provided. The steering control systems from the main and alternative steering stations are to be arranged so that failure of either system would not result in inability to steer the ship by means of the other system.

Means are to be provided to enable orders to be transmitted from the bridge to the alternative steering station.

**2707** The exact position of the rudder, if power operated, shall be indicated at the main steering station.

**2708** The after steering wheel and gear in ocean-going ships are to be adequately protected or situated in such a position that protection can be dispensed with.

**2709** The steering gear is to be secured to the seating by fitted bolts and suitable buttressing arrangements are to be provided.

### Tillers and Quadrants

**2710** The scantlings of tillers and quadrants are to be as given in Tables 49 and 50. Tillers and quadrants are to be shrunk on or bolted to the rudder head, in addition to being secured by a key of suitable dimensions. The keyways

are to have rounded ends. The thickness of quadrant plates is to be 1 per cent of the radius given in the Table. The area of the arms at ends may be one-third of the area given in Table 49. Arms of loose quadrants not keyed to the rudder head may be of these reduced dimensions throughout their length, and the depth of the boss may be reduced by 10 per cent.

**Rod and Chain Gears**

**2711** Steering rods and chains are to have the diameters required by Table 49 for the radius of quadrant given therein. Shackles, shackle pins, links and other connections are to be suitable for the size of chain.

**2712** All steering chains are to be subjected to the breaking and proof tests for short link chains given in P 13. These tests are to be carried out at a proving establishment recognised by the Committee and the certificates are to be produced.

**2713** The leads of the steering chains are to be as direct as possible and sharp bends are to be avoided. The diameters of leading block sheaves, measured at the centre of the chain, are to be not less than sixteen times the diameter of the steering chains; the pins of the sheaves are to have not less than twice the diameter of the chains.

**2714** A set of spares is to be provided consisting of one complete spring buffer and one extra spring, two tested chains each equal to the longest length in the gear, two Warwick screws, four shackles, four connecting links and four rod pins.

In ocean-going ships, the speed of which is 12 knots and above, one buffer spring, one Warwick screw and one length of chain may be dispensed with.

In ships engaged on short sea routes which have either a main gear which is hand operated at sea or an auxiliary gear, independent of the rods and chains, which can be effectively operated at sea, the spare gear may be confined to sufficient shackles or split links to enable repair of the gear to be readily effected in the event of its breakdown at sea. In all other ships engaged on short sea routes, the spare gear is to be as required for ships the speed of which is 12 knots and above.

**Springs**

**2715** Springs, buffers or equivalent arrangements are to be fitted to all main steering gears.

**Locking or Brake Gear**

**2716** An efficient locking or brake arrangement is to be fitted to all gears to keep the rudder steady when necessary.

In bow rudders where a vertical locking pin is operated from the deck above, positive means are to be provided to ensure that the pin can be lowered only when the rudder is exactly central. In addition, an indicator is to be fitted at the deck to show when the rudder is exactly central.

**Rudder Stops**

**2717** Stops for the rudder are to be provided and strongly secured to the deck in way of the tiller or quadrant tiller. Stops on the steering engine are to be arranged at a smaller angle of helm than those for the rudder.

## Section 28

### MASTS AND RIGGING

**Masts and Derrick Posts**

**2801** The scantlings of stayed and unstayed masts and derrick posts equipped with derricks of normal outreach intended for a working load not exceeding 8000 kg. each are to be determined from Table 51 and associated notes. For stayed masts the Table does not provide for more than one derrick plumbing any one hatch or for two derricks working outboard; the load for use in the Table is the working load of the heaviest derrick on the mast. For unstayed masts or derrick posts, the Table provides for two derricks working simultaneously in one direction and the load to be used in the Table is the sum of the working loads of the two derricks.

**2802** The scantlings and arrangements will be specially considered, if desired when:
the working load of any derrick exceeds 8000 kg.; or
the length of a derrick exceeds the length of the mast or derrick post by more than 20 per cent; or
the derrick heel fitting is more than 2,4 metres above the deck; or
for stayed masts, the arrangement of standing rigging differs from that given in 2804.

**2803** Masts and derrick posts are to be increased in thickness, or doubled, at the heel, deck and hounds and in way of the derrick fittings; they are to be efficiently supported below the heel. Plates exceeding 20,5 mm. are to be of Grade D steel.

**Standing Rigging**

**2804** Two shrouds, of standing rigging quality as defined in P 1404, are to be fitted on each side of stayed masts. The shrouds are to be attached at the sides of the ship at distances forward and aft of the mast each equal to one quarter of the beam of the ship or one quarter of the

length of the mast, whichever is the greater. The circumference of each shroud is to be 64 mm. where there are no derricks, 102 mm. where 4000 kg. derricks are fitted, and 127 mm. where 8000 kg. derricks are fitted. Alternative arrangements of standing rigging will be considered in conjunction with the scantlings of the masts. Topmasts are to be efficiently stayed.

**2805** Particular attention is to be paid to the strength and workmanship of all parts of the rigging and its connections. Smithwork is to be of best quality wrought iron or mild steel. The hull structure is to be effectively strengthened in way of chain plates or similar fittings. Standing rigging is to be properly set up.

**Masts with Outriggers**

**2806** Where outriggers at mast heads are of unusual spread the scantlings of masts and rigging will be specially considered.

**Cross-references**

**2807** For riveting, *see* Table 52 H.

For lightning conductors, *see* M 1801 to M 1806.

## Section 29

### CEILING AND CARGO BATTENS

**Ceiling**

**2901** In single bottom ships close ceiling is to be laid on the floors to the upper part of the bilges. Limber boards are to be arranged to provide easy access to the bilges.

**2902** In ships having double bottoms ceiling is to be laid over the bilges and under hatchways; the ceiling over the bilges is to be arranged with hatches which are readily removable. Ceiling under hatchways may be omitted provided the thickness of the inner bottom plating in way is increased by 2 mm.

**2903** The spaces between the frames at the top of the bilge ceiling are to be closed by wood chocks and cement or other suitable means.

**2904** Ceiling is to be laid either directly on the inner bottom plating embedded in a substantial composition such as Stockholm tar and cement, or on battens providing a clear space of at least 12,5 mm. for drainage. (*See* 2907.)

**2905** The thickness of wood ceiling is to be not less than 65 mm. in ships exceeding 61 metres in length nor less than 50 mm. in smaller ships.

**2906** Where the covers or fittings of the manholes of the inner bottom in cargo holds project above the plating they are to be protected by a steel coaming around each manhole, fitted with a hatch of wood or steel.

**Cross-references**

**2907** The requirements for ceiling over double bottom tanks where oil fuel is carried are given in D 2027.

**2908** For ceiling in ships which are to be regularly discharged by grabs, *see* D 525.

For arrangements in way of refrigerated holds, *see* N 415 and N 416.

**Cargo Battens**

**2909** Cargo battens are to be fitted in the holds from above the upper part of the bilge to the under side of beam knees, and in all cargo spaces in 'tween decks and superstructures up to the under side of beam knees.

**2910** Wood cargo battens are to be 50 mm. in thickness in ships exceeding 61 metres in length and 40 mm. in smaller ships; the clear space between the adjacent rows is not to exceed 230 mm.

**2911** Battens may be dispensed with at the request of the Owners; the notation "NS" will appear in the Register Book.

## Section 30

### PROTECTION OF STEELWORK

**Cementing**

**3001** In single bottom ships the shell plating and framing to the upper part of the bilges are to be effectively covered by an approved type of cement, asphalt or other coating. Free edges of the coating are to be of proper thickness, clear watercourses are to be maintained throughout.

**3002** In double bottom tanks under the boiler room the frames and shell plating are to be effectively covered by an approved type of cement or other coating unless the tanks are used solely for oil fuel; elsewhere in the double bottom the cement or coating may be dispensed with. The bilges are to be cemented or effectively coated.

**Painting**

**3003** All steelwork not protected as required by 3001 and 3002 is to receive at least two coats of paint of suitable

composition except inside tanks intended for oil; tanks not intended for oil may be coated with cement wash. (*See* F 822 and F 1005).

**General**

**3004** Millscale should be removed from external shell plating, and it is recommended that shot blasting, pickling or other equally effective means be employed for this purpose. If flame-cleaning is adopted, it is to be followed by wire brushing or grinding. Where reliance is placed on weathering and wire brushing, the coating of the external surface should be delayed as long as possible to facilitate the removal of the millscale.

**3005** Experience has shown that when several months elapse between the dates of launching and commissioning it is highly desirable to dry-dock ships immediately before going into service, in order to clean, examine and recoat the bottom. Experience has also shown the desirability of dry-docking for the same purpose when a ship has been about six months in service.

## Section 31

### WELDED CONSTRUCTION

**General**

**3101** Where electric arc welding is to be used for the main structure the arrangement of the plating, disposition and type of joints, together with the proposed sequence of prefabrication, assembly and welding, are to be submitted for approval. The extent to which automatic welding is to be used should be indicated.

Details of welded connections of main structural members with type and size of welds are to be clearly indicated on the plans submitted for approval.

The approved arrangements, sequences and procedures are not to be departed from without approval.

**3102** The structural arrangements are to be such as will admit of easy access for welding operations and will facilitate the use of downhand welding wherever possible.

The type and disposition of connections and sequences of welding are to be so planned that any restraint during welding operations is reduced to a minimum.

**3103** The electrodes are to be approved by the Committee and are to be suitable for the type of joint. The requirements for electrodes are given in P 15.

**Quality of Material**

**3104** For ships of 91,5 metres in length and over, in which the seams and butts of the shell plating and strength deck are welded, steel of Grade D (*see* P 2 Table II) will generally be required for the following parts of the main structure when the thickness exceeds 20,5 mm.:—

Sheerstrake, stringer plating and deck plating of strength deck within 0,4L amidships and plating at breaks of superstructures and corners of openings outside 0,4L amidships.

Bottom shell to upper turn of bilge within 0,4L amidships. When the bottom shell is of Grade D steel, the keel is also to be of that grade.

Any sheerstrake or stringer plate outside the above limits which exceeds 25,5 mm. in thickness should also be Grade D.

When necessary the application of the above requirements to ships less than 91,5 metres long will be specially considered.

**3105** In ships over 106,5 metres in length, a riveted stringer angle, or alternatively a gunwale construction incorporating steel of specially high notch toughness (Grade E), may be required.

**Refrigerated Ships**

**3106** In addition to the requirements of 3104, where the arrangements are such that the temperature of the steel of the deck may be reduced to that given below, the deck plating and the webs of girders attached thereto shall comply with the following requirements:—

STRENGTH DECK

| *Temperature* | *Grade of Steel* | |
|---|---|---|
| | 0,5L *amidships* | *At Ends* |
| Below +5° C. (41° F.) but not below −5° C. (23° F.) | D | D |
| Below −5° C. (23° F.) but not below −20° C. (−4° F.) | E | D |
| Below −20° C. (−4° F.) | Steel conforming to the requirements of Grade E at the temperature concerned. | |

SECOND AND LOWER DECKS

| | | |
|---|---|---|
| Below −5° C. (23° F.). | D | D |

Special consideration will be given to cases where the width of affected material is considerably less than the width of the hatchways.

**3107** For the purposes of 3106 the temperature to which the steel deck may be reduced is to be assessed as follows:—

| *Arrangement* | *Deck Temperature* |
|---|---|
| 1. Deck not covered with insulation in the refrigerated space. | Temperature of the refrigerated space. |
| 2. Deck covered with insulation in the refrigerated space and not insulated on the other side. | Temperature of the space on the uninsulated side. |
| 3. Deck covered with insulation on both sides. | (a) Mean of the temperatures of the spaces above and below the deck provided the difference in the temperatures is not more than 11° C. (20 F.)<br>(b) Mean of the temperatures of the spaces above and below the deck less 3° C. (5° F.) if the difference in the temperatures is more than 11° C. (20° F.) but not more than 33° C. (60° F.).<br>(c) When the temperature difference is more than 33° C. (60° F.) the deck temperature will be specially assessed. |

When one of the spaces concerned is not refrigerated, the temperature of that space is to be taken as 5° C. (41° F.).

**Structural Details**

**3108** Special attention is to be paid to structural continuity. Abrupt changes of shape or section and all sharp corners are to be avoided. The plating at corners of all openings in strength decks and shell plating is to be well rounded.

Where the deck is connected to the main hatchway coamings by welding, the deck opening and the coamings at the corners of the hatchways are to be rounded with a radius which, for openings within ·3L forward and aft of amidships, is not to be less than $\frac{1}{24}$ of the breadth of the opening; the minimum radius at all main hatchways in the strength deck is to be 150 mm.

If the deck plating extends inside the coamings the coamings may be square at the corners, provided that, within ·3L forward and aft of amidships, the side coamings are extended in the form of a tapered bracket and the deck plating at the corners is rounded as required by the preceding paragraph; the minimum radius is to be 300 mm. for hatchways within ·3L forward and aft of amidships or 150 mm. for those forward or abaft this region.

Where the deck is connected to the coamings by welding, the strength deck plating at the corners of all large openings is to be increased in thickness; welded doubling plates are not to be fitted. The seams and butts of the deck plating are to be kept well clear of hatch corners.

Where the deck plating stops at the coaming and is welded thereto, through penetration welds are to be used. Where the deck plating extends inside the coaming, the free edges of the plating in way of the hatchways are to be smooth and free of weld attachments.

Arrangements at the welded corners of machinery casings will be specially considered.

**3109** Bulwarks, fairlead stools, mouldings, or other fittings are not to be welded to the top of the sheerstrake within 0,5L amidships. The top edge of the sheerstrake is to be free of all notches and is to be smooth.

The endings of bulwarks, bilge keels or similar attachments to the hull are to be gradually tapered.

**3110** Frames, floors, stringers, girders, stiffeners and wash bulkheads in the aft peak, or on the aft peak bulkhead, are not to be scalloped and the connection to shell or bulkhead is to be by double continuous welds.

**3111** When stiffening members cross completely finished butt or seam welds, these welds are to be made flush in way of the faying surface. If the butt or seam welding is not completed, the web stiffening members are to be scalloped.

Scallops are to be fitted at the ends of the welded butts in the webs of stiffening members. Alternatively, a scallop may be omitted, provided the butt weld is completed and made flush with the plate before the fillet weld is made.

Bilge keels should also be scalloped at their butts, or alternatively, a 25 mm. hole should be drilled in the butt weld just above the fillet weld. In this case the fillet weld is to be continuous.

Local concentration of welds should be avoided.

Where thick plates are butt welded to thin plates the edge of the thick plate may require to be chamfered.

**3112** Individual connections part welded and part riveted are to be avoided and shall not be adopted unless specially approved.

**3113** The thickness of plating may in certain cases require to be increased to take account of the greater area of panels resulting from the omission of faying flanges of the supporting structure.

### Welded Joints and Connections

**3114** BUTT WELDS Butt welds should be adopted in preference to overlaps for joints in the main structure. In general, the edges of plates to be joined by manual welding are to be bevelled on one side or on both sides of the plates to provide an included angle of from 50 to 60 degrees.

Where it is desired to adopt other forms of edge preparation full details are to be submitted for approval.

A back sealing run is to be applied to all single V butt welds and to square edge butts where main welding is carried out from one side only.

**3115** FILLET WELDS The dimensions of fillet welds for various structural connections are to be as required by Table 52.

**3116** TEE CONNECTIONS The leg length of the fillets is to be governed by the thickness of the abutting plate or web. Where the difference between the thicknesses of the parts to be joined is considerable, the size of the fillet will be specially considered.

Tee connections should be made by fillets on both sides of the abutting plate. Where the abutting plate is bevelled a sealing run should be applied on the reverse side.

**3117** INTERMITTENT FILLETS The length of intermittent welds is to be measured over the correctly proportioned fillet, clear of end craters.

Intermittent fillets are to be doubled at, and carried round the end of brackets of, hold frames, longitudinals, beams, bulkhead and floor stiffeners, and of floors to shell, inner bottom and centre girder.

**3118** SCALLOPS AND NOTCHES The details of scalloped construction are given in Table 52 G. All scallops are to have well rounded corners and smooth edges. Scallops are not to be cut in way of the toes of bracket connections or at other parts where stress concentrations may develop.

Scallops in side frames, longitudinals and stiffeners are to be omitted for at least 230 mm. on each side of the intersection with a primary supporting member.

Notches in primary supporting members are not to be larger than necessary, and are to have well rounded corners and smooth edges. When notches occur at points where stress concentration may develop, such as adjacent to the toes of brackets, a welded collar or equivalent reinforcement is to be fitted.

### Additional Attachment

**3119** Welded connections may be required to be increased to meet particular local stresses, or where otherwise necessary.

### Overlap Joints

**3120** Where overlapped joints of plating are adopted, the breadth of the overlap is to be four times the thickness of the thinner of the plates so joined, but need not exceed 50 mm.

### Workmanship

**3121** Welding operators are to be proficient in the type of work on which they are engaged. A sufficient number of skilled supervisors is to be provided to ensure effective control at all stages of assembly and welding operations. The welding plant and appliances are to be suitable for the purpose intended and are to be maintained in an efficient condition.

**3122** Procedures for the welding of all joints are to be established for the types of electrode, edge preparation and welding position proposed. For this purpose, the Surveyors may require sample tests to be prepared under similar conditions to those which will obtain during construction.

The diameter of electrode, current, voltage, rate of deposit and number of runs are to conform, as far as practicable, to those established in accordance with the preceding paragraph. Provision is to be made for checking the current in the vicinity of the arc.

**3123** The preparation of plate edges is to be accurate and uniform. All joints are to be properly aligned and closed or adjusted before welding. Excessive force is not to be used in fairing and closing the work. Means are to be provided for holding the work in proper alignment without rigid restraint during welding operations.

Where excessive gaps exist between surfaces or edges to be joined, the corrective measures adopted are to be to the satisfaction of the Surveyors.

**3124** Tack welding should be kept to a minimum and where used the tack weld should be equal in quality to the finished welds. All defective tack welds should be cut out before completing the finished welds.

Care should be taken when removing tack welds and temporary fittings used for assembly to ensure that the material of the hull is not damaged.

**3125** The surfaces of all parts to be welded are to be clean, dry and free from rust, scale and grease. The surfaces and boundaries of each run of deposit are to be thoroughly cleaned and free from slag before the next run is applied.

Before a sealing run is applied to the back of a manual weld, the original root run is to be cut back to sound metal.

Welding is to proceed systematically, each welded joint being completed in proper sequence without undue interruption.

Adequate protection is to be provided where welding is required to be carried out in exposed positions in wet, windy or cold weather. In cold weather, precautions should be taken to screen and pre-warm the work to prevent too rapid cooling of the weld; special care is necessary when welding thick material.

**3126** All finished welds are to be sound, uniform and substantially free from slag inclusions, porosity, undercutting or other defects. Care is to be taken to ensure thorough penetration and fusion.

**3127** Where the structure embodies both welding and riveting, welded joints are in general to be completed before riveting in their vicinity.

**Inspection**

**3128** Effective arrangements are to be made for the inspection of finished welds to ensure that welding has been satisfactorily completed.

Visual inspection is to be supplemented by a system of radiographic examination or other approved method of non-destructive crack or flaw detection. The extent of such examination is to be to the Surveyor's satisfaction but particular attention should be paid to the following locations:—

(*a*) Junctions and crossings of seams and butts in strength deck, sheerstrake, side, and bottom shell within 0,5L amidships.

(*b*) Butts of keel plating and rounded sheerstrake within 0,5L amidships.

(*c*) Insert plates in way of hatch openings in the strength deck.

All defective sections of welds are to be cut out, carefully re-welded and re-examined.

**3129** Alternative proposals for methods of welding considered by the Committee to be equivalent to those set forth in the Rules will be accepted.

**Welding of Aluminium Alloys**

**3130** Where welding of aluminium alloys is employed, the requirements as laid down in this section are to be carried out in so far as they are applicable, with the following additions:—

The edges of the material to be welded are to be clean and freed from grease by chemical or solvent cleaning.

The joint edges should be scratch brushed—preferably immediately before welding—in order to remove oxide or adhering films of dirt, filings, etc.

Parts to be welded should be set up in such a way that contraction stresses are kept to a minimum.

For welding processes and filler wire, *see* P 18.

## Section 32

### RIVETED CONSTRUCTION

**Riveted Connections**

**3201** The requirements for riveted connections and the diameter and spacing of rivets in the various parts of the structure are given in Table 52. The diameter of the rivets is to be regulated, in general, by the greater thickness of the parts to be connected, but where the difference is considerable special consideration will be given. (*See also* Notes to Table 52.) Where frame spacing wider than that given in the Tables is adopted the diameter and the number of rows of rivets are to be regulated by the thickness of the plating required at the Table frame spacing.

**3202** The breadths of the flanges of connecting angles or other sections are to be generally not less than four times the diameter of the rivet for rivets up to 22 mm. in diameter and three and one-half times for rivets of 25 mm. diameter or over.

**3203** Chain riveting is to be adopted for the butts and seams of plating. In the connections to bar keels, stems and sternframes and in double riveted stringer angles, boundary angles and frame connections, the rivets are to be reeled.

**Form of Rivets**

**3204** Rivets are to be suitably formed to fill the rivet holes completely. Where the holes have been punched the rivets are to be increased under their heads. The heads of pan headed rivets are to have a depth of 0,7 and a diameter at the bottom of the head of 1,6 times the diameter of the rivet. Where countersunk headed rivets are used the heads are to be suitable for the countersinking of the material.

**Countersinking**

**3205** Rivet holes are to be countersunk on the caulking side of plating, and in boundary connections of shell, weather decks, inner bottom, double bottom tank ends, crowns and bulkheads of peak tanks, deep tanks and oil fuel bunkers. The holes in the margin plate to take gusset rivets are also to be countersunk.

**3206** The countersinking of the holes is to extend through at least nine-tenths of the thickness of the plates or angles where the thickness does not exceed 12,5 mm. and through at least eight-tenths where the thickness is above 12,5 mm.

**3207** The angle of countersink for material not exceeding 12,5 mm. in thickness is to be about 60 degrees; for plating exceeding this thickness the angle is to be about 45 degrees.

### Workmanship

**3208** Workmanship is to be well executed and submitted to close inspection throughout the preparation and building of the ship. The various parts of the structure are to be faired and properly closed.

**3209** Punches, dies and shears are to be maintained in good condition and the clearance between the punch and the die is to be kept as small as possible.

### Plating

**3210** The preparation of plate edges is to be accurate and uniform. Shearing is to be carried out from the faying surface wherever practicable. Any burr on plates or sections preventing the closing of work is to be removed.

**3211** All caulking edges are to be planed, flame cut, chipped fair, or otherwise suitably prepared.

### Liners and Joggling

**3212** Where plates or sections are joggled care is to be taken that the joggle is of the correct depth and rivet holes are to be clear of the joggle.

**3213** Liners, if fitted, are to be in one piece of the proper thickness and of breadth not less than the flange of the faying section. Holes in liners are to be of the same diameter as those in the plate and section.

### Riveting

**3214** Rivet holes may be drilled or punched and are to be countersunk where required by 3205 to 3207. Punching is to be carried out from the faying surface wherever practicable.

**3215** Any burr caused by drilling or punching is to be removed before the work is closed for riveting.

**3216** Unfair rivet holes are to be remedied by reamering and rivets of an appropriate diameter are to be used. Where necessary the holes are to be recountersunk and the faying surfaces cleaned.

**3217** Rivet holes in the frames at the turn of the bilges and at bossing are not to be drilled or punched to their full diameter before the frames have been shaped.

**3218** Service bolts of requisite size and number are to be used to hold the parts in position and in close contact.

**3219** The heads of the rivets are to be properly laid up and the work performed so that the holes are completely filled. Points of the rivets are to be kept full but are not to be spread over the plating. In holes which are not countersunk the rivets are to be finished with specially full or snap points.

**3220** Rivets in all parts are to be spaced to ensure the efficient closing of work. Particular care is to be taken with three-ply riveting.

### Caulking

**3221** Caulking is to be thoroughly executed. Stopwaters of suitable material may be fitted where necessary; otherwise the use of soft packing is to be kept to a minimum. Thick packing is not to be used.

### Oil-tight Riveted Work

**3222** The requirements of 3201 to 3221 are to be complied with.

**3223** Faying surfaces are, in general, to be fitted steel to steel; but where packing is necessary the material used is to be as thin as possible and not soluble in oil.

**3224** Where there may be difficulty in securing fairness, rivet holes are to be drilled in position or punched small and reamered.

**3225** Where boundary angles are double both flanges of each bar are to be caulked and countersunk headed rivets are to be used.

**3226** Where fitted on caulking surfaces angle or T-bar connections are to be caulked.

**3227** Attachments of fittings are to be made as far as possible without piercing the plating; where through fastenings are necessary they are to be tapped and efficiently secured to the plating.

## Section 33

## EQUIPMENT

### General

**3301** The regulations governing the assignment of the figure 1 for equipment are contained in B 201 and B 202.

**3302** To entitle a ship to the figure 1 the equipment is to be in accordance with the following requirements and Table 53. For ships engaged on a special or restricted

service an equipment less than the Table requirements may be approved by the Committee if considered suitable for the particular service on which the ship is to be engaged.

**Equipment Number**

**3303** The equipment of anchors, chain cables, wires and ropes given in Table 53 and associated notes is based on an " Equipment Number " which is to be the sum of the numbers calculated as follows:—

1. For the Hull:—

   Number=L (B + d) + 0,85 L (D − d).

   (For definitions of L, B, D and d *see* D 201 to D 204; D is to be measured to the uppermost continuous deck except that, for ships without sheer in way of 0,5L amidships the depth may be taken as 97 per cent of the depth moulded amidships.)

2. For Superstructures, i.e., for those parts of the structure which extend athwartships to the side of the ship or are set inboard not more than 305 mm. also for continuous trunkways:—

   Number=0,85 (l × h)

   where l=overall length of superstructure, including rounded ends, in metres,

   h=height from deck to deck, in metres.

   Projections beyond the length l, i.e., structure not extending to, or within 305 mm. of, the side of the ship may be treated as Other Erections. (*See* 3 below.)

   Where promenade spaces are enclosed by screens at the side of the ship, the length so enclosed is to be treated as superstructure.

3. For Other Erections:—

   Number=0,75 (h×l)

   where h=height, in metres,

   l=overall length, in metres.

The following need not be included in computing the number:—

(*a*) All parts outside the length L.

(*b*) Isolated erections when both length and breadth are less than one-half B.

(*c*) Hatch coamings unless forming part of a continuous trunkway.

**Anchors**

**3304** Anchors are to be of approved design. The radii on all parts of the anchor head are to be as large as possible, particularly where there is a considerable change of section. The heads of stockless anchors, including pins and fittings, are not to be less than 60 per cent of the total weight of the anchor. Where anchors with stocks are provided the weight of the stock is to be 25 per cent of the total weight of the anchor including shackle, etc., but excluding stock.

**Chain Cables**

**3305** Chain cables may be of wrought iron, mild steel or special quality steel in accordance with the requirements of P 13. The form and proportions of the links and lugless or D shackles are to be in accordance with recognised practice.

**Testing of Equipment**

**3306** All anchors and chain cables are to be tested at establishments and on machines recognised by the Committee under the supervision of the Society's Surveyors or other officer recognised by the Committee, and in accordance with the requirements of P 11, P 12 and P 13.

Test certificates showing particulars of weights of anchors, or size and weight of cable and of the test loads applied are to be furnished. These certificates are to be examined by the Surveyors when the anchors and cables are placed on board the ship.

**3307** Steel wire ropes are to be tested as required by P 14.

**Arrangements for Working and Stowing Anchors and Cables**

**3308** A windlass of sufficient power and suitable for the size of chain cable is to be fitted and efficiently bedded and secured to the deck. The thickness of the deck in way of the windlass is to be increased and adequate stiffening is to be provided, to the Surveyor's satisfaction.

**3309** An easy lead of the cables from the windlass to the anchors and chain locker is to be arranged.

**3310** Hawse pipes are to be of ample thickness and of a suitable size and form to house the anchors efficiently. Substantial chafing lips are to be provided at the shell and deck. The shell plating and framing in way of the hawse pipes are to be reinforced as necessary.

**3311** The chain locker is to be of a capacity and depth adequate to provide an easy direct lead for the cable into the chain pipes, when the cable is fully stowed. Chain or spurling pipes are to be of suitable size and provided with chafing lips. The port and starboard cables are to be separated by a division in the locker, and provision is to be made for securing the inboard ends of the cables to the structure.

**3312** Satisfactory arrangements are to be made for the stowage and working of the stream anchor if provided.

**Cross-reference**

**3313** For the equipment of tugs, *see* D 3511.

## Section 34

### RECOMMENDATIONS IF ADDITIONAL STRENGTHENING FOR HEAVY CARGOES IS DESIRED

**General**

**3401** The following recommendations are inserted for the guidance of Owners who desire to provide additional strengthening to ships regularly engaged in onerous heavy cargo trades. (For Bulk Carriers, *see* D 37).

**3402** Where the class contemplated includes loading other than homogeneous, schemes of loading covering the cargo and ballast conditions envisaged are to be submitted for approval.

**3403** The scantlings, arrangements and equipment should be as required by Sections D 1 to D 33, modified as follows.

**Structural Design**

**3404** The double bottom and strength deck should be longitudinally framed.

**Double Bottom Structure**

**3405** Plate Floors. Under cargo holds abaft 0,25L from forward plate floors should be fitted on alternate frames in way of the hatchways, but may be on every third frame, with maximum spacing of 2,45 metres clear of hatchways.

**3406** Inner Bottom Longitudinals. The section modulus of the inner bottom longitudinals shall be derived from Table 10 and associated notes increased by 20 per cent in way of the hatchways and 10 per cent clear of the hatchways.

Struts should not be fitted to the longitudinals between the floors.

**3407** Centre Girder. When the maximum spacing of the plate floors is 2,45 metres, the height of the centre girder should be increased 20 per cent above that required by Table 6; when the maximum spacing of floors is 1,85 metres or less, the height of the centre girder may be as required by Table 6.

**3408** Side Girders. Side girders should be not less than required by D 503.

An additional side girder should be fitted abaft the engine room, extending the full length of the hold.

**3409** Inner Bottom Plating. The thickness of the inner bottom plating should be increased by 5 mm. above the requirements of Table 6 or alternatively double ceiling should be fitted.

**Side Framing**

**3410** In the holds the height of the tank side brackets above the tank top as required by Tables 6 and 11 should be maintained. The arms of the lower deck beam knees should be increased by 150 mm. and the riveting correspondingly increased. The frames and beams should not be reduced in size on account of this increase.

**Decks**

**3411** The sectional area of the strength deck plating as derived from Table 18 and associated notes should be increased by 10 per cent for 0,4L amidships.

**3412** Strong Hatch Side Coamings and End Beams under Cargo Decks. The scantlings should be determined by the numeral derived from the notes to Table 29 increased by 10 per cent.

## Section 35

### TUGS

**General**

**3501** The scantlings and arrangements of tugs are to be as required by the preceding Sections of this Chapter except where otherwise specified in this Section.

The draught d used for determination of scantlings, is not to be less than 0,85D.

**Class**

**3502** Tugs built in accordance with the requirements of this Section will be classed 100A1 tug.

**3503** Where tugs are intended for service in sheltered waters only, the class will be A1 tug with a class notation indicating the limits of the service. Suitable modifications in the scantlings, arrangements and equipment may be approved by the Committee.

**Floors**

**3504** Floors in tugs having single bottoms may be flanged 90 mm. on the upper edge instead of having reversed frames, except in the engine room and under the boiler bearers where double reversed frames are to be fitted as required by D 407.

**Keelsons**

**3505** The scantlings of keelsons are to be in accordance with the requirements for tugs given in Table 5.

**Bulkheads**

**3506** Watertight bulkheads are to be constructed generally as required by D 16, but the stiffeners may be determined from Table 35.

**Machinery Casings**

**3507** Machinery casings are to be not less in height than 915 mm. above the upper surface of the deck.

Casings extending to the bottom of the beams are to be connected to the beams; the deck connection may be made by a single riveted angle or equivalent. If the casings do not extend to the bottom of the beams the casing connection to the deck is to be double riveted or equivalent.

**3508** Machinery casings are to be made watertight and hose tested.

**3509** A strong through beam is to be fitted at the deck level between the engine room and boiler room openings. A through beam should also be fitted in motor tugs when the machinery opening is of considerable length, and the casing stiffened by webs.

**Panting and Strengthening of Bottom Forward**

**3510** The arrangements to resist panting, required by D 9, do not apply to tugs below 45,7 metres in length. In tugs 45,7 metres or more in length additional stiffening is also to be fitted in the 'tween decks throughout the panting region.

The requirements of D 8 for strengthening of bottom forward do not apply to tugs.

**Equipment**

**3511** The regulations governing the assignment of the figure 1 for equipment, are defined in B 201 and B 202. The equipment is to be determined from Table 54 and associated notes. The equipment number is to be L (B+D) without addition for casings or other erections. (*See* D 3303.)

## Section 36

### DREDGERS AND HOPPER BARGES

**General**

**3601** The scantlings and arrangements of dredgers and hopper barges are to be as required by the preceding Sections of this Chapter except where otherwise specified in this Section.

The draught d, used for the determination of scantlings, is generally to be that corresponding to the minimum freeboard, but when a restricted draught is desired, this may be used with a minimum value of 0,7D.

**Class**

**3602** These rules apply to two classes of ships; those intended to work in estuaries or adjacent waters and proceeding only a short distance outside coastal limits for the purpose of dumping spoil, and those which are required to proceed considerable distances to sea for the purpose of dumping spoil or are intended to make regular voyages between ports. Ships in the former category will be classed 100A1 Dredger, 100A1 Hopper Dredger or 100A1 Hopper Barge, with a suitable service notation; those in the latter will not have a service limit.

The rules are basically designed to cover ships having a restricted geographical service and the increases required for an unrestricted service are also given.

**3603** When dredgers and hopper barges are intended for service in sheltered waters only, the class will be A1 Dredger, A1 Hopper Dredger or A1 Hopper Barge with a class notation indicating the limits of the service. Suitable modifications in the scantlings, arrangements and equipment may be approved.

**3604** When dredgers and hopper barges are to be classed for unrestricted service but, while operating in restricted waters, may be loaded to a draught greater than that used for determining scantlings, particulars of the draught desired and service limits are to be submitted for approval. If the resulting freeboard is less than the minimum assignable under the Load Line Convention the agreement of the appropriate national or local authorities may also be required.

**Longitudinal Strength**

**3605** In way of the hopper the modulus of the section is not to be less than:—

$$\frac{I}{y} = \frac{(6{,}6737L^2 + 26{,}247L + 11000)}{4{,}732} Bd \text{ cm}^3$$

where L = length of ship, in metres (*see* D 201),
B = moulded breadth, in metres,
d = scantling draught, in metres.

In computing the modulus all continuous material (e.g., hopper sides, bottom, deck and hopper side longitudinals) is to be included.

**3606** Consideration will be given to the required section modulus for dredgers or barges not having service limits and also to those with relatively short hoppers. In

these cases particulars of the main hull and machinery weights, displacement, etc., are to be provided to enable a longitudinal strength calculation to be made. Alternatively, the Builders' calculation of still water bending moment is to be submitted.

**Floors**

**3607** Where single bottoms are fitted the depth of the floors may be 5 per cent less than that given in Table 4, and the floors may be flanged on the upper edge instead of having reversed frames, except in the engine room and under the boiler bearers where double reverse frames are to be fitted. Where floors are flanged the breadth of the flange is to be the same as that of the horizontal flange of the reverse frame required by Table 4.

**3608** The floors abreast the hopper or well opening may be 5 per cent less in depth than required by Table 4, based on a breadth equal to the breadth of the ship B minus the total breadth of the hopper or well openings. The depth of the floors is not, however, to be less than 70 per cent of the depth based on the full value of B.

**3609** Floors abreast the hopper are to be bracketed at each end but clear of the hopper the brackets may be omitted provided suitable compensation is arranged.

**Side Keelsons**

**3610** Clear of the hopper opening side keelsons are to be fitted as required by D 412 and D 416.

A side keelson is to be fitted in the buoyancy space abreast the hopper opening when the distance between the hopper opening and the ship's side exceeds 3,65 metres.

**Longitudinal Framing**

**3611** Where longitudinal framing is adopted either with a double bottom or in association with open floors, the modulus of the longitudinals may be 10 per cent less than that given by Table 10 and associated notes except for unrestricted service.

**3612** Where the longitudinals are supported by open floors the scantlings of the floors are to be as given by the following formula:—

$$\frac{I}{y} = C \times l^2 \times s \times D \text{ cm.}^3$$

where $l$ = span of floor, in metres, measured to the mid-points of the end brackets,

$s$ = spacing of floors, in metres,

$D$ = depth of ship to upper deck at amidships, in metres,

$C$ = 10,0 for restricted service or 10,845 for unrestricted service.

The modulus of the floor is to be calculated in association with 610 mm. of shell plating.

The depth of the floor is not to be less than $2\frac{1}{2}$ times the depth of the slot for the longitudinal.

**Side Framing**

**3613** The side frames clear of the hopper are generally to be in accordance with the requirements of D 6. The modulus may be 10 per cent less than required by Tables 12 and 13, except for unrestricted service (*see also* 3617). The depth h to be used in Table 12 is to be measured at 0,25L from the fore end, for framing between that point and the collision bulkhead.

**Shell Plating**

**3614** The shell plating and sheerstrake are to be generally in accordance with the requirements of D 7 and Tables 14 and 18, but the thickness given in the Tables may be reduced by 5 per cent except for unrestricted service. In transversely framed ships with welded bottom plating the thickness of the plating need not be increased as required by D 708; the shell stiffeners required by that paragraph are to be fitted, but the scantlings of the stiffeners may be reduced in ships less than 76,2 metres in length.

**3615** The corners of hopper openings are to be well rounded, but doublings or plating of increased thickness need not be fitted except for unrestricted service.

**Strengthening of Bottom Forward**

**3616** The requirements of D 8 for strengthening of bottom forward do not, in general, apply to dredgers and hopper barges.

Where the service is unrestricted, the midship thickness of the bottom shell plating (clear of hopper) is to be carried to the fore peak bulkhead and the requirements of D 805 and D 806 complied with.

**Arrangements to resist Panting**

**3617** Strengthening to resist panting is not required to be fitted between 0,15L from the fore end and the collision bulkhead except that for unrestricted service the strength of the framing in this area is to be increased by 10 per cent.

**Hopper**

**3618** In way of the hopper the side framing and hopper side stiffening may be arranged either transversely or longitudinally. Where transverse framing is fitted the side frames and hopper side stiffeners are to be supported by struts, or stringers in association with struts, or equivalent arrangements, except in very small vessels. Where longitudinal framing is fitted, the longitudinals are to be supported by webs or transverses.

**3619** The transverse side frames are to be in accordance with the requirements of D 6 and, except for unrestricted service, the modulus may be 10 per cent less than required by Table 12, the depth h being measured to the upper deck amidships. Where struts or stringers in association with struts are fitted, the modulus of the frames so determined may be reduced by 20 per cent. The hopper side stiffeners where fitted transversely are to be determined as deep tank stiffeners from Table 40, H being taken to the overflow and length being measured along the stiffener; the modulus so obtained may be reduced by 20 per cent where struts or stringers in association with struts are fitted.

**3620** Side frames or hopper side stiffeners arranged longitudinally are to have a modulus not less than:—

$$\frac{I}{y} = C_1 \times l^2 \times s \left(h + \frac{D}{6}\right) \text{ cm.}^3 \text{ for frames, and}$$

$$\frac{I}{y} = C_2 \times l^2 \times s \times h^1 \text{ cm.}^3 \text{ for hopper side stiffeners}$$

where $l$ = distance between webs or transverses, in metres,
$s$ = spacing of longitudinals or stiffeners, in metres,
$h$ = distance of longitudinal below deck at side, in metres,
$h^1$ = distance of longitudinal stiffeners below overflow, in metres,
$D$ = moulded depth, in metres,
$C_1$ = 7,746 for restricted service and 8,435 for unrestricted service,
$C_2$ = 9,037 for restricted service and 9,989 for unrestricted service.

**3621** The section modulus of transverses supporting longitudinal side frames or hopper side stiffeners is not to be less than:—

$$\frac{I}{y} = C_3 \times l^2 \times s \times h \text{ cm.}^3 \text{ for shell transverses, and}$$

$$\frac{I}{y} = C_4 \times l^2 \times s \times h^1 \text{ cm.}^3 \text{ for bulkhead transverses}$$

where $l$ = span of transverse, in metres, measured to mid-point of end bracket,
$s$ = spacing of transverses, in metres,
$h$ = head from mid-point of span to deck at side, in metres,
$h^1$ = head from mid-point of span to overflow, in metres,
$C_3$ = 9,989 for restricted service and 10,845 for unrestricted service,
$C_4$ = 10,845 for restricted service and 11,862 for unrestricted service.

The depth of the transverse is not to be less than $2\frac{1}{2}$ times the depth of the slot for the longitudinal.

**3622** The thickness of the hopper side plating is not to be less than that required for the side shell plating, corrected as necessary for the spacing of the transverse or longitudinal stiffeners. It is recommended that the thickness of the lower strake be increased.

**3623** In hoppers having no centre line box girder the strake of bottom shell plating adjacent to the hopper opening should not be less in thickness than required for a garboard strake.

**3624** Continuity of strength is to be maintained at the ends of the hopper. Hopper side plating and other longitudinal members are to be suitably scarphed into the fore and aft structure. Increased topside plating in way of hopper is to be extended well forward and aft of the hopper ends.

**3625** The bulkheads at the ends of hoppers are to be as required for the boundary bulkheads of deep tanks (D 19), the head being taken to the overflow.

**3626** The sides of the hopper are to be connected at bottom and deck level by substantial cross-members at suitable intervals. These are to be in line with transverse bulkheads or suitable webs inside the buoyancy spaces and centre line box girder if fitted. Where a centre line box girder is fitted it should be of ample strength with suitable arrangements for resisting docking stresses. The cross-members at the bottom of the hopper should be of substantial construction to carry the loads imposed on them when the ship is placed in drydock or when the hopper is fully loaded. If a gangway is fitted above the hopper carrying the supports of bottom doors, the cross-members at deck level should be of ample strength to carry the loads imposed on them by this gangway and the weight of spoil supported.

**Decks**

**3627** In way of the hopper the deck thickness is to be such as to satisfy the requirements of 3605 and 3606.

**3628** Clear of the hopper the scantlings of the strength deck are to be determined from D 11 and Table 18 and associated notes, but the sectional area required may be reduced by 10 per cent except for unrestricted service.

**3629** The corners of the hopper opening are to be well rounded, and doublings or plating of increased thickness need not be fitted except for unrestricted service.

**3630** Where the seams and butts of the shell plating and deck are welded, steel of Grade D (*see* P 2, Table II)

will generally be required for the following parts of the structure when the thickness exceeds 20,5 mm:—

Sheerstrake, stringer plate, deck plating, bottom shell plating and heavy plates at corners of hopper openings in shell and deck.

**Beams and Deck Longitudinals**

**3631** The scantlings of the upper deck beams or longitudinals are to be determined from Tables 24 and 26 and associated notes, except that clear of the hopper the value of K may be taken as 1,00 irrespective of the value of $\frac{d}{D}$. Forward of 0,12L the Table factor K is to be applied (irrespective of draught) where the service is unrestricted.

**Equipment**

**3632** The equipment number is to be calculated in accordance with the provisions of D 3303.

**3633** The equipment for the figure 1 may be one grade below the requirements of Table 53.

The equipment for the class A1 will be specially considered.

**Other Items**

**3634** Additional strengthening is to be fitted in way of ladder gallows and dredging machinery.

**3635** Access to the hopper keelson space is to be provided by means of watertight manholes or watertight doors capable of being operated from both sides.

**3636** The hopper keelson space is to be adequately ventilated.

**3637** It is recommended that no part of the structure in way of the hopper and the hopper side tanks shall have a thickness less than $6,6+\frac{L}{36}$ millimetres, where L = length of ship, in metres, or 8,5 mm. whichever is the greater.

## Section 37

### BULK CARRIERS

**General Design**

**3701** For the purpose of this Section a Bulk Carrier is a single deck ship exceeding 122 metres in length with machinery aft.

Attention should be given to the amount and distribution of water ballast. It has been found that satisfactory service has been obtained when the draught forward is not less than 0,027L and the longitudinal radius of gyration of the ballasted ship is about 0,25L.

**3702** The preceding Sections of this Chapter apply to Bulk Carriers except as amended and amplified in the following.

**Class Notations**

**3703** When one of the following class notations is desired:—

"Strengthened for Heavy Cargoes",
"Strengthened for Heavy Cargoes—Specified holds may be empty",
"Strengthened for Ore Cargoes",
"Strengthened for Ore Cargoes—Alternate (or specified) holds may be empty",

the relevant additional requirements of this Section are to be complied with.

**Longitudinal Strength**

**3704** The required section modulus at deck and keel for the various class notations is to be determined with reference to a basic modulus M.

$$M = k\,B\,(C_b+0,70)\times 10^5 \text{ cm.}^3$$

where k is to be determined from Table A,

$C_b$ is the moulded block coefficient at a draught of 0,06L,

B is the moulded breadth, in metres.

**TABLE A**

| LENGTH | k | LENGTH | k |
|---|---|---|---|
| Metres | | Metres | |
| 120 | 1,476 | 185 | 3,830 |
| 125 | 1,606 | 190 | 4,074 |
| 130 | 1,744 | 195 | 4,329 |
| 135 | 1,891 | 200 | 4,594 |
| 140 | 2,046 | 205 | 4,868 |
| 145 | 2,210 | 210 | 5,150 |
| 150 | 2,382 | 215 | 5,440 |
| 155 | 2,563 | 220 | 5,739 |
| 160 | 2,752 | 225 | 6,047 |
| 165 | 2,950 | 230 | 6,364 |
| 170 | 3,157 | 235 | 6,690 |
| 175 | 3,372 | 240 | 7,025 |
| 180 | 3,596 | 245 | 7,369 |

**3705** The basic modulus for the class 100A1 or for the various class notations is given in Table B and Notes which also gives the maximum permissible still water bending moment (in the loaded condition) allowed in association with this modulus.

**TABLE B**

| CLASS | BASIC $I_{/Y}$ | | PERMISSIBLE STILL WATER BENDING MOMENT |
|---|---|---|---|
| | KEEL | DECK | |
| | cm.³ | cm.³ | Tonnes metres. |
| 100A1 Strengthened for Ore Cargoes (See Note 1) | M (See Note 2) | 0,93M | $5,12 \times M \times 10^{-3}$ (See Notes) |
| 100A1 or 100A1 Strengthened for Heavy Cargoes... (See Note 1) | 0,90M | 0,90M | $6,3 \times 0,90M \times 10^{-3}$ |

**NOTES TO TABLE B**

1. The assignment of a class notation that alternate or defined holds may be empty does not affect the basic section modulus.

2. With the notation "Strengthened for Ore Cargoes" the keel modulus may be 0,93M if the still water bending moment in the loaded condition (homogeneous in all holds or defined holds) is hogging. If the sagging stress at the keel in the loaded condition is less than 5,12 kg. per mm.² the required modulus may be obtained by interpolation between:—

| SAGGING STRESS AT KEEL | REQUIRED KEEL MODULUS |
|---|---|
| 5,12 | M |
| Nil | 0,93M |

The permissible still water bending moment is then:—

$5,12 \times 10^{-3} \times$ required keel modulus

3. If the actual still water bending moment exceeds the permissible the required section modulus at the keel becomes:—

$$\frac{I}{y} = \frac{M_1 + \frac{2 \times \text{actual S.W.B.M.}}{f \times 10^{-3}}}{3} \text{ cm.}^3$$

where $M_1$ is the required modulus at keel as obtained from Table B and Note 2,

f is 5,12 for the notation "Strengthened for Ore Cargoes", or

6,3 for the class 100A1 or for the notation "Strengthened for Heavy Cargoes".

The section modulus at the deck should be increased in the same proportion as the keel modulus.

4. The permissible still water bending moment in the ballast condition is:—

$6,3 \times M_1 \times 10^{-3}$ tonnes metres

for all bulk carriers.

If the actual still water bending moment exceeds this value the section modulus is not to be less than:—

$$\frac{I}{y} = 0,30M + \frac{\text{actual S.W.B.M.}}{9,45 \times 10^{-3}} \text{ cm.}^3$$

**3706** When a notation is desired permitting certain holds to be empty the maximum still water bending moment may not occur at amidships and shearing force and bending moment curves are to be submitted. In these cases the approved loading must be incorporated in the Trim and Stability Booklet issued to the ship.

**3707** All continuous longitudinal material is to be included in the calculation of the inertia of the section and the lever "y" is to be measured from the neutral axis to the top of keel and to the moulded deck line at side. For requirements with continuous coamings *see* 3708.

**3708** Where continuous hatch coamings are arranged 80 per cent of the area of the continuous hatch coamings may be included in the calculation of the section modulus and the lever "y" is to be measured

(*a*) to the moulded deck line at side amidships

(*b*) to a point a distance above the moulded deck line at side amidships equal to the height of the hatch coaming above the deck.

The modulus with "y" measured as in (*a*) is to be 5 per cent greater than required by 3705 and with "y" measured as in (*b*) the modulus may be 10 per cent less than required by 3705.

**Extent of Midship Scantlings**

**3709** The midship scantlings are to extend over the following lengths each side of midships:—

| | AFT | | | FORWARD | | |
|---|---|---|---|---|---|---|
| | H.C. | O. | Alt. | H.C. | O. | Alt. |
| Bottom | 0,2L | 0,25L | 0,25L | 0,2L | 0,2L | 0,25L |
| Side | 0,2L | 0,25L | 0,25L | 0,2L | 0,25L | 0,25L |
| Sheerstrake | 0,2L | 0,25L | 0,25L | 0,2L | 0,2L | 0,25L |
| Deck | 0,2L | 0,25L | 0,25L | 0,2L | 0,2L | 0,25L |
| Centre girder and tank top | 0,2L | 0,25L | 0,25L | 0,2L | 0,2L | 0,25L |

H.C.—Strengthened for Heavy Cargoes (or the class 100A1 without special notation).

O. —Strengthened for Ore Cargoes.

Alt. —Strengthened for Heavy (or Ore) Cargoes—Specified holds may be empty.

**Grades of Steel**

**3710** Where the thickness of plating exceeds 20,5 mm. and the seams (other than those covered by 3711) and butts

are welded, steels of grade D (*see* P 2, Table II) will generally be required for the following parts of the structure:—

(*a*) Sheerstrake, strength deck stringer and plating, top strake of the topside tank, deck longitudinals of the slab type where cut from plates and through brackets for deck longitudinals from 0,2L aft of amidships to 0,2L forward of amidships, but at least 3 metres forward of the bridge front. Where a notation is desired that certain holds may be empty, the limits are to be 0,25L.

Sheerstrake and strength deck stringer and plating in way of poop front.

Any stringer, or sheerstrake plating outside the above limits of the midship portion which is above 25,5 mm. in thickness.

Plating at corners of openings, irrespective of position, if exceeding 20,5 mm. in thickness.

(*b*) Bottom shell plating to upper turn of bilge, bottom longitudinals of the slab type cut from plates and through brackets of bottom longitudinals from 0,15L aft of amidships to 0,15L forward of amidships where the length is 152,4 metres and below, and from 0,25L aft of amidships to 0,2L forward of amidships where the length is 213,4 metres and above with intermediate values obtained by interpolation. Where a notation is desired that certain holds may be empty the limits are to be 0,25L.

Where the bottom plating is required to be of steel of grade D, the keel plate is also to be of the same grade.

**3711** Strakes of grade E steel are to be arranged as follows:—

| LENGTH L | | GRADE E STRAKES |
|---|---|---|
| OVER | NOT EXCEEDING | |
| Metres | Metres | |
| 167,6 | 198,1 | Sheerstrake |
| 198,1 | | Sheerstrake<br>Bilge Strake |

The grade E strakes are to extend between 0,2L aft and 0,2L forward except that when a notation is desired that certain holds may be empty the extent is to be 0,25L aft and forward.

The breadth of each strake is not to be less than 1525 mm. except that the bilge strake shall not be less than 1830 mm.

The use of riveted seams as an alternative to strakes of grade E steel will be specially considered.

**3712** For scantlings and arrangements if higher tensile steel is used *see* D 65, D 66 and D 67.

**Double Bottom Structure**

**3713** Paragraphs 3714 to 3722 do not apply where the class desired is 100A1 without a special notation; the requirements of D 5 are then applicable.

**3714** The bottom structure is to be framed longitudinally. In the forward 0,25L the requirements of D 806 are to be complied with where these are in excess of those given below.

**3715** The basic arrangements of floors and longitudinals for the various class notations are as given in Table C, but alternative arrangements will be specially considered.

**3716** The thickness of plate floors and plate longitudinals are to be those given in Table 6 Col. 10 and Col. 12 respectively, increased by the appropriate percentages given in Table C.

**3717** If the bottom longitudinals are rolled sections their section modulus is not to be less than that derived from Table 10 and associated notes. Where the length L exceeds 150 metres the value derived from the Table for a length of 150 metres is to be multiplied by $\frac{L}{150}$.

**3718** If the inner bottom longitudinals are rolled sections their section modulus is not to be less than:—

$$\frac{I}{y} = \frac{S^2 \times s \times H}{C} \text{ cm.}^3$$

where S is the span, in metres,

s is the spacing of the longitudinals, in mm,

H is the height from tank top to deck at side amidships, in metres,

C is 77,25 for the notation "Strengthened for Heavy Cargoes",

61,45 for the notation "Strengthened for Ore Cargoes",

$$37{,}30 \times \frac{\text{cargo stowage rate (cubic metres/1000 kg) of specified holds}}{0{,}418}$$

(but not to exceed 61,45) for the notation "Strengthened for Ore (or Heavy) Cargoes—specified holds may be empty".

"Stowage rate" is the cubic capacity of holds divided by the cargo deadweight or, in specific cases, is the cubic capacity of a particular hold divided by the weight of cargo stowed therein.

Where plate longitudinals are fitted alternately with rolled sections, but are not required by Table C, the required modulus of the rolled sections may be reduced by 10 per cent.

**3719** If longitudinals are fitted to the sloping tank top forming a hopper side tank their section modulus is not to be less than required by 3718 with H measured from the centre of the sloping portion.

**3720** The thickness of the inner bottom plating is to be increased 5 mm. above the requirements of Table 6 or alternatively double ceiling is to be fitted.

**3721** The height of centre girder should not be less than given by Table 6 and associated notes but may be required to be increased so that the section modulus of the girder formed by a floor in association with shell and tank top plating of width equal to the floor spacing is not less than given by:—

$$\frac{I}{y} = C \times S^2 \times s \times D \text{ cm.}^3$$

where S is (breadth of level tank top + 1,52) metres,

s is spacing of floors, in metres,

D is depth of ship, in metres,

C is 4,55 for the notation "Strengthened for Heavy Cargoes",

4,75 for the notations "Strengthened for Ore Cargoes" or "Strengthened for Heavy Cargoes—specified holds may be empty",

4,95 for the notation "Strengthened for Ore Cargoes—specified holds may be empty".

**3722** The number of side girders is not to be less than required by D 503.

**Bottom Shell**

**3723** The thickness of the bottom shell amidships to upper turn of bilge is to be that necessary to give the required section modulus but is not to be less than:—

$$\left(\frac{L}{12}+4\right)-0{,}01\ (915-s) \text{ mm.}$$

where L is the length, in metres,

s is the spacing of longitudinals, in mm.

The breadth and thickness of the keel plate are to be in accordance with Table 14, Note 1.

**TABLE C**

| ITEM | NOTATION | | |
|---|---|---|---|
| | H.C. | O. | Alt. |
| Plate floors—number | On alternates | On alternates | On alternates |
| ,, ,, thickness | +10% if longitudinals rolled sections | +10% | +10% |
| Longitudinals—type | Rolled sections permitted | Rolled sections permitted | Plate longitudinals and rolled sections alternately |
| Thickness of plate longitudinals (if fitted) and arrangement of openings therein | +15% if large openings. No increase if only manholes | +10% and only manholes | +10% and only manholes |

H.C.—Strengthened for Heavy Cargoes
O. —Strengthened for Ore Cargoes.
Alt. —Strengthened for Heavy (or Ore) Cargoes—Specified holds may be empty.

**Side Shell**

**3724** The thickness of the side shell plating amidships is not to be less than:—

$$9{,}15(L+380)\,(d+9{,}145)\,(s+1015)\times10^{-7} \text{ mm.}$$

where L is the length, in metres, (but need not be taken as greater than 228,6),

d is moulded draught, in metres,

s is the spacing of frames or longitudinals, in mm.

If the shear force diagram (*see* 3706) shows that the shear stress exceeds 5,9 kg. per mm.$^2$ the shell is to be stiffened by intermediate frames or increased in thickness in way of the excessive shear stress. If the shear stress exceeds 7,88 kg. per mm.$^2$ special reinforcement will be required. The shear stress at the neutral axis is to be calculated as:—

$$\frac{100\times F\times A\bar{y}}{I\times t} \text{ kg. per mm.}^2$$

where F = shearing force, in tonnes,

$A\bar{y}$ = first moment of area of the longitudinal material above the neutral axis, in cm.$^3$,

I = moment of inertia of the transverse section, in cm.$^4$,

t = 2×side shell thickness, in mm.

**Side Framing**

**3725** The scantlings of hold frames amidships are to be obtained from Table 12 and associated notes using a value "h" measured from the double bottom tank top, or top of hopper side tank, to the underside of the topside tank or deck.

When a hopper side tank is fitted the modulus derived as above may be multiplied by $(1-\frac{x}{2D})$ where x is the height of the hopper side tank above the base, in metres, and D is the moulded depth in metres.

**3726** The size, spacing and fore and aft extent of web frames for the various class notations are to be as given in Table D.

**TABLE D**

| CLASS | Maximum Spacing of Webs | Fore and Aft Extent | SIZE | |
|---|---|---|---|---|
| | | | Minimum Depth | Minimum Face Area sq. cm. |
| 100A1 ... ... ... ... | 8 frame spaces | 0,1L fore and aft of amidships | d (*see* notes) | $\frac{d\,S}{180}$ |
| 100A1 Strengthened for Heavy Cargoes ... ... ... ... | 8 frame spaces | Throughout Cargo Holds | d | $\frac{d\,S}{180}$ |
| 100A1 Strengthened for Heavy Cargoes. Specified holds may be empty ... ... ... | 4 frame spaces | Throughout Cargo Holds | 1,2d | $\frac{d\,S}{150}$ |
| 100A1 Strengthened for Ore Cargoes ... ... ... ... | 8 frame spaces | Throughout Cargo Holds | 1,2d | $\frac{d\,S}{150}$ |
| 100A1 Strengthened for Ore Cargoes. Alternate (or specified) holds may be empty ... ... | 4 frame spaces | Throughout Cargo Holds | 1,2d | $\frac{d\,S}{150}$ |

**NOTES TO TABLE D**

1. $d = 6{,}8\,S\left(\frac{L}{100}\right)^3 + 40\,S$ mm. with a minimum of 355 mm.

where S = span, in metres, measured at shell between hopper tank and topside tank but not less than $\frac{3D}{8}$,

L = length of ship, in metres,

D = moulded depth of ship, in metres.

2. The modulus of the web frame (in association with 610 mm. of plating) is not to be less than 1,5 times that of the adjacent main frame.

3. The depth of the web may require to be increased when the size of the topside tank is unusually large.

**Topside Tanks**

**3727** The scantlings of topside tanks are not to be less than required for deep tanks. (The minimum head is to be taken as that at the half-width of the tank). The sloping plating is not to be less than required by Table 20, col. 5.

**3728** Webs, transverses or wash bulkheads are to be arranged in line with the web frames required by 3726.

**3729** When a notation is desired that certain holds may be empty a fore and aft diaphragm plate, extending from the deck to the bottom of the topside tank, is to be fitted about mid-way between the ship's side and the hatch side or alternative arrangements provided.

**Sheerstrake**

**3730** The radius of a rounded sheerstrake should, in general, not be less than 15 times the thickness. The radius should be made by careful cold rolling or bending. The thickness of the sheerstrake should generally not be less than 85 per cent of the stringer plate.

**Bulkheads**

**3731** Where the class notation includes a reference to ore cargoes watertight hold bulkheads are not to be less than 10 mm. in thickness except that vertically corrugated bulkheads are not to be less than 11 mm.

**Passageways**

**3732** Where fore-and-aft underdeck passageways are arranged at the ship's side, the after access thereto is to be by a watertight trunk led to the upper deck. Alternative arrangements to prevent the engine room being flooded in the event of a collision if the passageway doors are left open will be considered.

*November, 1964*

# TABLES OF SCANTLINGS AND EQUIPMENT


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## ROLLED SECTIONS

The moduli given in the Tables represent the Rule standard; the scantlings given are those of the nearest acceptable section shown in Table 56

# BAR KEELS AND STEMS

| LENGTH L | BAR KEELS | STEMS |
|---|---|---|
| Metres | Millimetres | Millimetres |
| **30** | 150 × 25 | 125 × 25 |
| **40** | 170 × 33 | 135 × 29 |
| **50** | 180 × 42 | 145 × 36 |
| **60** | 190 × 50 | 155 × 41 |
| **70** | 205 × 55 | 165 × 45 |
| **80** | 215 × 59 | 185 × 49 |
| **90** | 225 × 63 | 200 × 53 |
| **100** | 240 × 67 | 210 × 58 |
| **110** | 260 × 70 | 220 × 62 |
| **120** | | 230 × 66 |
| **130** | | 240 × 70 |
| **140** | | 260 × 75 |
| **150** | | 275 × 76 |
| **160** | | 285 × 76 |
| **170** | | 295 × 80 |
| **180** | | 300 × 85 |
| **190** | | 305 × 89 |
| **200** | | 305 × 97 |

# TABLE 2

## STERNFRAMES WITH APERTURES

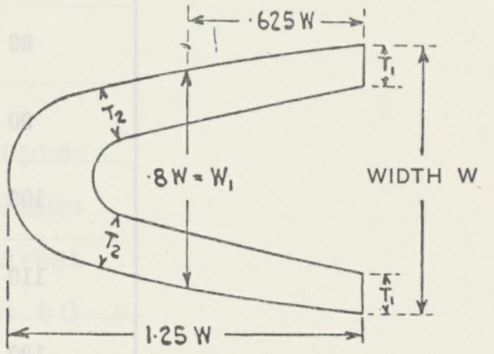
| LENGTH L | WIDTH AND THICKNESS | | | | | | |
|---|---|---|---|---|---|---|---|
| | SOLID | | CASTING | | | BUILT | |
| | WIDTH | | WIDTH | THICKNESS | | WIDTH | THICKNESS |
| | Rectangular | Streamlined W | W | $T_1$ | $T_2$ | W | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Metres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres |
| **30** | 65 | | | | | | |
| **40** | 80 | | | | | | |
| **50** | 95 | | | | | | |
| **60** | 115 | 150 | 205 | 19 | 32 | 255 | 20 |
| **70** | 130 | 170 | 220 | 24 | 36 | 270 | 21 |
| **80** | 145 | 190 | 235 | 28 | 40 | 285 | 22 |
| **90** | 165 | 210 | 250 | 31 | 44 | 300 | 23 |
| **100** | 180 | 225 | 260 | 33 | 46 | 320 | 25 |
| **110** | 195 | 240 | 270 | 36 | 51 | 335 | 27 |
| **120** | 205 | 250 | 285 | 38 | 56 | 350 | 29 |
| **130** | 215 | 260 | 295 | 41 | 60 | 370 | 31 |
| **140** | 225 | 270 | 305 | 44 | 63 | 385 | 32 |
| **150** | 235 | 280 | 315 | 45 | 63 | 400 | 33 |
| **160** | 245 | 285 | 325 | 47 | 64 | 420 | 34 |
| **170** | 250 | 290 | 335 | 49 | 64 | 435 | 35 |

### NOTES.—TABLE 2

1. The dimensions given in the Table apply to both propeller post and rudder post.

2. The fore and aft dimension of the section is to be 25 per cent greater than its width as given in cols. 2, 3, 4 and 7 but is not to be less than 125 mm.

3. The width w given in cols. 3, 4 and 7 for streamlined solid, cast or built sternframes is the extreme width. The width $w_1$ at half the fore and aft dimension of the section is assumed to be 80 per cent of the extreme width. (See sketch.)




Where the section of sternframe adopted differs from that given above an equivalent section modulus is to be obtained.

4. The solepiece in way of the aperture is to be extended in an athwartship direction to a width 50 per cent greater than that given in col. 2 ; the vertical dimension is to be equal to the width in col. 2. If a rudder post is not fitted the scantlings of the solepiece will be specially considered.

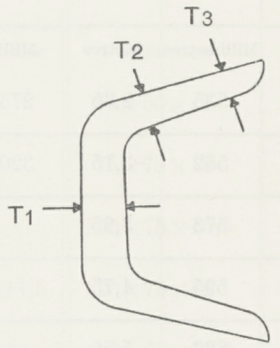
5. The boss of the propeller post is to have a finished thickness of metal round the bore equal to 60 per cent of the width given in col. 2.

6. The scantlings given in cols. 5, 6 and 8 are minima.

7. For scantlings of gudgeons *see* D 313.

# STERNFRAMES OF TWIN SCREW SHIPS

| LENGTH L | SOLID | CASTINGS | | |
|---|---|---|---|---|
| | WIDTH | THICKNESS | | |
| | | $T_1$ | $T_2$ | $T_3$ |
| Metres | Millimetres | Millimetres | Millimetres | Millimetres |
| 40 | 34 | | | |
| 50 | 42 | | | |
| 60 | 50 | 27 | 23 | 15 |
| 70 | 58 | 30 | 25 | 17 |
| 80 | 66 | 34 | 27 | 20 |
| 90 | 74 | 39 | 29 | 23 |
| 100 | | 44 | 32 | 25 |
| 110 | | 49 | 35 | 28 |
| 120 | | 54 | 38 | 30 |
| 130 | | 60 | 42 | 33 |
| 140 | | 65 | 46 | 35 |
| 150 | | 71 | 49 | 37 |
| 160 | | 77 | 53 | 40 |
| 170 | | 84 | 56 | 42 |
| 180 | | 91 | 61 | 44 |
| 190 | | 98 | 66 | 46 |
| 200 | | 105 | 71 | 47 |




**NOTES.—TABLE 3**

1. Fore and aft dimensions of solid sternposts are to be three times the width.

2. The side flanges of cast steel sternposts are to have dimensions sufficient to take the shell connection.

# TABLE 4

## FLOORS IN

| DEPTH D | FRAME SPACING AMIDSHIPS | BASIC DRAUGHT $d_b$ | BREADTH B METRES | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Metres | Millimetres | Metres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres |
| 3 | 535 | 2,35 | 275×6 | 295×6,5 | 320×6,5 | 355×7 | 385×7 | 405×7,5 | | |
| 4 | 552 | 3,15 | 320×6,5 | 340×6,5 | 360×7 | 395×7,5 | 440×8 | 480×8,5 | | |
| 5 | 573 | 3,95 | | | | 440×7,5 | 480×8 | 520×8,5 | 565×9 | 605×9 |
| 6 | 595 | 4,75 | | | | | | 565×9 | 605×9 | 645× 9,5 |
| 7 | 620 | 5,55 | | | | | | | 645×9,5 | 690×10 |
| 8 | 662 | 6,35 | | | | | | | | 730×10 |
| 9 | 705 | 7,15 | | | | | | | | |

### NOTES.—TABLE 4

1. **Corrections.**

FOR DRAUGHT.

If d is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than $d_b$ depth of floors is to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ at the rate of 12,5 mm. per 0,3 metre of difference.

FOR FRAME SPACING.

If the spacing amidships is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than that given in the Table the thickness of the floors and of the reversed

## SINGLE BOTTOMS

| BREADTH B METRES | | | | | | | | REVERSED FRAMES | DEPTH D |
|---|---|---|---|---|---|---|---|---|---|
| 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | | |
| Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Metres |
| | | | | | | | | 75×65× 7 | 3 |
| | | | | | | | | 75×75× 9 | 4 |
| | | | | | | | | 100×75×10,5 | 5 |
| 680×10 | 730×10 | 800×10 | 850×10,5 | 880×11 | 935×11 | 935×11,5 | 980×11,5 | 130×75×12 | 6 |
| 725×10 | 770×10,5 | 815×10,5 | 875×11 | 905×11,5 | 960×11,5 | 960×12 | 1010×12 | 150×75×13,5 | 7 |
| 765×10,5 | 815×10,5 | 855×10,5 | 915×11 | 950×11,5 | 990×12 | 1040×12 | 1040×12,5 | 150×75×14,5 | 8 |
| | 850×10,5 | 885×11 | 915×11,5 | 950×12 | 1030×12 | 1040×12,5 | 1080×12,5 | 150×90×18,5 | 9 |

**NOTES.—TABLE 4** *(concluded)*

frames is to be $\frac{\text{increased}}{\text{reduced}}$ at the rate of 0,5 mm. and 1 mm. respectively for every 100 mm. of difference.

2. **Increases in machinery spaces.**—In the engine room the floors are to be increased 1 mm. and in the boiler room the floors and the reversed frames are to be increased 2,5 mm. beyond the thicknesses given in the Table.

# TABLE 5

## KEELSONS IN SINGLE BOTTOMS

| LENGTH L | CENTRE KEELSONS | | | | | | SIDE KEELSONS | |
|---|---|---|---|---|---|---|---|---|
| | PLATE KEEL ANGLES | | DOUBLE TOP ANGLES | THICKNESS OF VERTICAL PLATES AND FOUNDATION PLATES IF FITTED | | BREADTH OF FOUNDATION PLATES IF FITTED | SINGLE TOP ANGLE | THICKNESS OF INTERCOSTAL PLATE |
| | FOR 0,4L AMIDSHIPS | THICKNESS FOR 0,1L FROM ENDS | THROUGHOUT | FOR 0,4L AMIDSHIPS | THICKNESS FOR 0,1L FROM ENDS | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Metres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres |
| **30** | 75×75× 6,5 | 6,5 | 75×75× 6,5 | 7,5 | 6,5 | 250 | 100×75× 7,0 | 6,0 |
| **40** | 75×75× 8,0 | 7,5 | 90×75× 7,5 | 8,5 | 7,0 | 275 | 100×75× 7,5 | 6,5 |
| **50** | 75×75× 8,5 | 8,0 | 100×75× 8,0 | 9,5 | 7,5 | 295 | 100×75× 8,0 | 7,0 |
| **60** | 90×90× 9,5 | 9,0 | 110×75× 8,0 | 10,0 | 8,5 | 325 | 130×75× 8,5 | 8,0 |
| **70** | 90×90×10,5 | 10,0 | 130×75× 8,5 | 10,5 | 9,0 | 370 | 130×75× 8,5 | 8,5 |
| **80** | 90×90×10,5 | 10,0 | 130×75× 9,5 | 11,0 | 9,0 | 410 | 130×75× 9,0 | 9,0 |
| **90** | 90×90×11,0 | 10,5 | 150×75×10,0 | 11,5 | 9,5 | 450 | 130×75×10,0 | 9,5 |
| **100** | 90×90×11,5 | 11,0 | 160×90×10,5 | 12,0 | 10,0 | 490 | 130×75×11,0 | 10,0 |

## KEELSONS IN TUGS

| LENGTH L | CENTRE KEELSON ON TOP OF FLOORS WITH BAR KEEL | | SIDE KEELSON ON TOP OF FLOORS |
|---|---|---|---|
| | SINGLE CHANNEL | DOUBLE BULB ANGLES | SINGLE ANGLE |
| Metres | Millimetres | Millimetres | Millimetres |
| **30** | 200×85×11,0 | 150×75× 8,0 | 130×100× 9,0 |
| **35** | 220×90×11,0 | 150×75× 9,5 | 130×100× 9,5 |
| **40** | 220×90×12,0 | 165×75× 9,5 | 130×100×10,0 |
| **45** | 240×95×13,0 | 165×75×10,5 | 130×100×10,5 |
| **50** | 260×95×14,0 | 180×75× 9,5 | 130×100×11,5 |

**NOTES.—TABLE 5**

**In boiler rooms** the thickness of the centre and side keelsons, foundation plates and angles not covered by cement is to be increased by 2,5 mm.

# TABLE 6 DOUBLE BOTTOMS

| LENGTH L | FRAME SPACING AMIDSHIPS | CENTRE GIRDER | | | | | MARGIN PLATE | | FLOOR PLATES, GIRDERS AND BRACKETS INSIDE TANK | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | THICKNESS | | | THICKNESS | | THICKNESS | | |
| | | BASIC DRAUGHT $d_b$ | HEIGHT ABOVE BASE LINE | FOR 0,4L AMIDSHIPS | FOR 0,1L FROM ENDS | IN BOILER ROOM | IN HOLDS AND ENGINE ROOM | IN BOILER ROOM | FLOORS IN HOLDS AND ENGINE ROOM. SIDE GIRDERS IN ENGINE ROOM | FLOORS AND SIDE GIRDERS IN BOILER ROOM | SIDE GIRDERS IN HOLDS |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Metres | Millimetres | Metres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres |
| **40** | 560 | 2,4 | 665 | 8,0 | 6,5 | 10,5 | 7,0 | 9,5 | 6,5 | 9,0 | 6,5 |
| **50** | 580 | 3,0 | 665 | 9,0 | 7,5 | 11,5 | 8,0 | 10,5 | 7,0 | 9,5 | 7,0 |
| **60** | 600 | 3,6 | 710 | 10,0 | 8,5 | 12,5 | 9,0 | 11,5 | 7,5 | 10,0 | 7,0 |
| **70** | 620 | 4,2 | 750 | 10,5 | 9,0 | 13,0 | 9,5 | 12,0 | 8,0 | 10,5 | 7,5 |
| **80** | 640 | 4,8 | 790 | 11,0 | 9,0 | 13,5 | 10,0 | 12,5 | 8,0 | 10,5 | 7,5 |
| **90** | 660 | 5,4 | 845 | 11,5 | 9,5 | 14,0 | 10,5 | 13,0 | 8,5 | 11,0 | 8,0 |
| **100** | 680 | 6,0 | 915 | 12,0 | 10,0 | 14,5 | 11,0 | 13,5 | 9,0 | 11,5 | 8,5 |
| **110** | 700 | 6,6 | 970 | 12,5 | 10,5 | 14,5 | 11,5 | 14,0 | 9,5 | 12,0 | 8,5 |
| **120** | 720 | 7,2 | 1050 | 13,0 | 11,0 | 15,0 | 12,5 | 14,5 | 10,0 | 12,5 | 9,0 |
| **130** | 740 | 7,8 | 1110 | 13,5 | 11,5 | 15,5 | 13,0 | 15,0 | 10,5 | 13,0 | 9,5 |
| **140** | 760 | 8,4 | 1175 | 13,5 | 11,5 | 15,5 | 13,5 | 15,5 | 10,5 | 13,0 | 9,5 |
| **150** | 780 | 9,0 | 1235 | 14,0 | 12,0 | 16,0 | 14,0 | 16,0 | 11,0 | 13,5 | 10,0 |
| **160** | 800 | 9,15 | 1250 | 14,5 | 12,5 | 16,5 | 15,0 | 16,5 | 11,5 | 14,0 | 10,5 |
| **170** | 820 | 9,15 | 1290 | 15,0 | 13,0 | 17,0 | 16,0 | 17,5 | 12,0 | 14,0 | 11,0 |
| **180** | 840 | 9,15 | 1310 | 15,5 | 13,5 | 17,0 | 16,5 | 18,0 | 12,5 | 14,5 | 11,0 |
| **190** | 860 | 9,15 | 1325 | 16,0 | 14,0 | 17,5 | 17,0 | 18,5 | 13,0 | 14,5 | 11,5 |
| **200** | 880 | 9,15 | 1350 | 16,5 | 14,5 | 17,5 | 18,0 | 19,0 | 13,5 | 15,0 | 12,0 |

## NOTES.—TABLE 6

**1. Corrections.**

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than $d_b$ the height of the centre girder to be $\frac{\text{increased}}{\text{reduced}}$ at the rate of 12,5 mm. for each 0,3 metre of difference.

FOR FRAME SPACING.

If the spacing amidships is $\frac{\text{greater}}{\text{less}}$ than that given in col. 2 the thickness of the floor and bracket plates, margin plate and inner bottom plating to be $\frac{\text{increased}}{\text{reduced}}$ at the rate of 0,5 mm. for every 100 mm. of difference.

If, in transversely framed ships, the spacing amidships exceeds the Table spacing by 100 mm. or more the increase required will be specially considered.

The thickness of the inner bottom plating in the engine and boiler rooms and of the middle line strake throughout should not be corrected for frame spacing but is not to be less than the thickness derived from col. 16 after correction.

The thickness of watertight floors is to be 2 mm. greater than the thickness given in col. 10, but need not exceed 13,5 mm.

| INNER BOTTOM PLATING | | | | | | | ANGLE CONNECTIONS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MIDDLE LINE STRAKE EXCEPT IN BOILER ROOM | | | REMAINDER | | | | ANGLES CONNECTING CENTRE GIRDER TO FLAT PLATE KEEL | | ANGLES CONNECTING CENTRE GIRDER TO INNER BOTTOM | | | |
| BREADTH | THICKNESS | | | | | | | | | | ANGLES CONNECTING MARGIN PLATE TO SHELL PLATING | LENGTH L |
| | FOR 0,4L AMIDSHIPS | FOR 0,1L FROM ENDS | IN HOLDS: FOR 0,4L AMIDSHIPS | IN HOLDS: FOR 0,1L FROM ENDS | IN ENGINE ROOM | IN BOILER ROOM INCLUDING MIDDLE LINE STRAKE | FOR 0,4L AMIDSHIPS | THICKNESS FOR 0,1L FROM ENDS | FOR 0,4L AMIDSHIPS | THICKNESS FOR 0,1L FROM ENDS | | |
| 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Metres |
| 960 | 7,0 | 6,5 | 6,5 | 6,5 | 7,5 | 10,5 | 75× 75× 8,0 | 7,5 | 65×65× 7,0 | 7,0 | 75×75× 7,5 | **40** |
| 1000 | 7,5 | 7,0 | 7,0 | 7,0 | 8,0 | 11,0 | 75× 75× 9,0 | 8,5 | 75×75× 7,5 | 7,5 | 75×75× 8,0 | **50** |
| 1040 | 8,5 | 8,0 | 8,0 | 7,5 | 9,0 | 12,0 | 75× 75×10,0 | 9,5 | 75×75× 8,0 | 8,0 | 75×75× 9,0 | **60** |
| 1080 | 9,5 | 8,5 | 8,5 | 8,0 | 10,0 | 12,5 | 90× 90×10,5 | 10,0 | 75×75× 9,0 | 8,5 | 75×75×10,0 | **70** |
| 1120 | 10,0 | 8,5 | 8,5 | 8,0 | 10,0 | 13,0 | 90× 90×11,0 | 10,5 | 75×75× 9,5 | 9,0 | 75×75×10,5 | **80** |
| 1160 | 10,5 | 9,0 | 9,0 | 8,5 | 10,5 | 13,0 | 90× 90×11,0 | 10,5 | 75×75×10,0 | 9,5 | 90×90×11,5 | **90** |
| 1205 | 11,5 | 9,5 | 9,5 | 8,5 | 11,5 | 13,5 | 90× 90×11,5 | 11,0 | 75×75×10,5 | 10,0 | 90×90×11,5 | **100** |
| 1245 | 12,0 | 10,0 | 10,0 | 9,0 | 12,0 | 14,0 | 90× 90×12,0 | 11,5 | 75×75×11,0 | 10,5 | 90×90×12,0 | **110** |
| 1285 | 12,5 | 10,5 | 10,5 | 9,5 | 12,5 | 14,0 | 90× 90×12,5 | 12,0 | 90×90×11,5 | 10,5 | 90×90×12,5 | **120** |
| 1330 | 13,0 | 11,0 | 11,0 | 10,0 | 13,0 | 14,5 | 130×130×13,0 | 12,5 | 90×90×11,5 | 10,5 | 90×90×13,0 | **130** |
| 1370 | 13,0 | 11,0 | 11,0 | 10,0 | 13,0 | 15,0 | 130×130×13,5 | 12,5 | 90×90×12,0 | 11,0 | 90×90×13,5 | **140** |
| 1410 | 14,0 | 12,0 | 12,0 | 11,0 | 14,0 | 15,0 | 130×130×14,0 | 13,0 | 90×90×12,5 | 11,5 | 90×90×14,0 | **150** |
| 1455 | 14,5 | 12,5 | 12,5 | 11,5 | 14,5 | 15,5 | 130×130×15,0 | 13,5 | 90×90×13,5 | 12,0 | 90×90×14,0 | **160** |
| 1495 | 15,0 | 13,0 | 13,0 | 12,0 | 15,0 | 16,0 | 130×130×15,5 | 14,0 | 90×90×14,0 | 12,5 | 90×90×14,0 | **170** |
| 1535 | 16,0 | 14,0 | 13,5 | 12,5 | 16,0 | 16,5 | 130×130×16,0 | 14,5 | 90×90×14,0 | 13,0 | 90×90×14,0 | **180** |
| 1580 | 16,5 | 14,5 | 14,0 | 13,0 | 16,5 | 17,0 | 130×130×17,0 | 15,5 | 90×90×14,0 | 13,5 | 90×90×14,0 | **190** |
| 1640 | 17,0 | 15,0 | 14,5 | 13,5 | 17,0 | 17,0 | 130×130×17,5 | 16,0 | 90×90×14,0 | 13,5 | 90×90×14,0 | **200** |

**NOTES.—TABLE 6** *(concluded)*

2. **Depth of margin plate** is not to be less than 80 per cent of the depth of centre girder corrected by note 1, where the length of the ship does not exceed 105 metres, or 85 per cent where the length is 125 metres and above, with intermediate values in proportion. At the after end the depth may be reduced to 85 per cent of the depth amidships.

3. **Thickness of connecting angles not given in Table.**—The thickness of the vertical angles connecting intercostal girders to floors is not to be less than that of the intercostal plate. The thickness of the frames, reversed frames and other connecting angles is not to be less than the thickness of the floors.

4. **Width of faying flanges.**—For width of faying flanges for all angles, unless specified in the Table, *see* D 3202.

5. **In boiler rooms** angles not covered by cement are to be increased by 2,5 mm. in thickness.

6. **Oil fuel.**—For thickness of inner bottom plating when oil fuel is carried in the double bottom, *see* D 2021.

# TABLE 7

## BRACKET FLOORS

| DEPTH D | FRAME SPACING AMIDSHIPS | BASIC DRAUGHT $d_b$ | *CORRECTION TO MODULUS PER 0,3 METRE DIFFERENCE BETWEEN d and $d_b$* | UNSUPPORTED SPAN METRES | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1,00 | 1,25 | 1,50 | 1,75 | 2,00 | 2,25 | 2,50 |
| Metres | Millimetres | Metres | Per cent | MILLIMETRES *Modulus—Centimetres³* | | | | | | |
| 4 | 552 | 3,18 | *9,4* | 100×75× 9,5 *34,2* | 120×75×10 *49,1* | 140×75× 9 *59,2* | | | | |
| 5 | 573 | 4,02 | *7,6* | 120×75× 9 *44,6* | *63,9* | 150×75×10,5 *77,4* | *84,8* | *92,4* | 150×75× 8,5 *107* | 165×75× 8,5 *132* |
| 6 | 595 | 4,75 | *6,3* | 130×75× 9,5 *55,0* | 150×75×10,5 *78,8* | *96,2* | *105* | 150×75× 9,0 *114* | 165×75× 8,5 *132* | 180×75× 8,5 *163* |
| 7 | 620 | 5,58 | *5,4* | 140×75×10,5 *67,8* | *96,5* | 150×75× 9,5 *118* | 150×75×10,5 *128* | 165×75× 9,0 *140* | 180×75× 8,5 *162* | 180×90×11,5 *197* |
| 8 | 662 | 6,42 | *4,7* | 150×75×11 *81,8* | 150×75× 9,5 *117* | 165×75× 9,5 *142* | 165×75×10,5 *155* | 180×90× 9,0 *171* | 180×90×11,5 *198* | 200×90×10,5 *235* |
| 9 | 705 | 7,15 | *4,2* | *98,1* | 165×75× 9,0 *139* | 180×90× 9,0 *170* | 180×90×10,5 *186* | 180×90×11,5 *204* | 200×90×11,0 *239* | *284* |
| 10 | 748 | 7,98 | *3,8* | 150×75× 9,5 *116* | 180×75× 8,5 *165* | 180×90×11,5 *200* | *219* | 200×90×11,0 *242* | *280* | 230×90×12,0 *340* |
| 11 | 790 | 8,82 | *3,4* | 165×75× 8,5 *135* | 180×90×11 *192* | 200×90×10,5 *233* | 200×90×12 *258* | *282* | 230×90×11,0 *322* | 250×90×11,0 *397* |
| 12 | 830 | 9,15 | *3,2* | *148* | *210* | 200×90×12 *256* | *286* | *312* | 230×90×12,5 *349* | 250×90×12,5 *435* |
| 13 | 870 | 9,15 | *3,2* | *156* | *221* | 200×90×13 *268* | *302* | 230×90×11,0 *328* | 230×90×13,5 *367* | 250×90×13,5 *459* |
| 14 | 912 | 9,15 | *3,2* | *164* | 200×90×10,5 *232* | *281* | *316* | 230×90×12,0 *344* | *384* | *481* |
| 15 | 955 | 9,15 | *3,2* | 180×90× 9,5 *172* | 200×90×11 *242* | *294* | 230×90×11,5 *332* | 230×90×13,0 *361* | 250×90×11,0 *401* | *499* |

ANGLES / BULB ANGLES

### NOTES.—TABLE 7

1. **Scantlings.**—The bottom frames are to have scantlings determined from the Table ; the modulus of the reversed frames may be 85 per cent of that of the bottom frames corrected as required below. For width of faying flanges *see* D 3202.

2. **Correction to modulus of frames.**

FOR DRAUGHT.

If d is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than $d_b$, modulus to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ by the percentage given in the Table per 0,3 metre of difference.

FOR FRAME SPACING.

If the spacing amidships differs from that given in the Table, modulus to be modified in direct proportion.

3. **In boiler rooms**, frames, reversed frames, struts and angle connections are to be increased by 2,5 mm. in thickness.

4. Particulars of sections and moduli are given in Table 56.

# DETAILS OF BRACKET FLOORS

| DEPTH OF FRAME | | RIVETS IN BRACKETS | | RIVETS IN EACH END OF VERTICAL BAR ON INTERCOSTAL GIRDER | | VERTICAL STRUTS BETWEEN INTERCOSTAL GIRDER AND CENTRE LINE OR MARGIN PLATE | | RIVETS IN EACH END OF VERTICAL STRUTS | |
|---|---|---|---|---|---|---|---|---|---|
| | | NUMBER | DIAMETER | NUMBER | DIAMETER | | | NUMBER | DIAMETER |
| 1 | | 2 | 3 | 4 | 5 | | 6 | 7 | 8 |
| Millimetres | | | Millimetres | | Millimetres | | Millimetres | | Millimetres |
| **90 and 100** | ANGLES | 4 | 16 | 2 | 16 | ANGLES | 150×75×8,5 | 2 | 16 |
| **130** | ANGLES | 5 | 16 | 2 | 16 | ANGLES | 150×75×9,0 | 3 | 16 |
| **150** | ANGLES | 5 | 19 | 2 | 19 | CHANNELS | 200×85×85×11,0 | 4 | 19 |
| **130 and 140** | BULB ANGLES | 5 | 19 | 2 | 19 | CHANNELS | 200×85×85×11,0 | 4 | 19 |
| **150** | BULB ANGLES | 6 | 19 | 2 | 19 | CHANNELS | 200×85×85×11,0 | 4 | 22 |
| **180** | BULB ANGLES | 7 | 19 | 3 | 19 | CHANNELS | 200×85×85×11,0 | 4 | 22 |
| **200** | BULB ANGLES | 8 | 19 | 4 | 19 | CHANNELS | 220×90×90×11,0 | 5 | 22 |
| **230** | BULB ANGLES | 8 | 22 | 4 | 22 | CHANNELS | 240×95×95×12,0 | 6 | 22 |
| **250 and above** | BULB ANGLES | 9 | 22 | 4 | 22 | CHANNELS | 260×95×95×12,0 | 6 | 22 |

**NOTES.—TABLE 8**

1. **In boiler rooms** struts are to be increased by 2,5 mm. in thickness.

2. For scantlings of welded vertical struts *see* D 515.

# TABLE 9 STIFFENERS TO WATERTIGHT FLOORS

Spaced 760 millimetres apart

| DEPTH OF CENTRE GIRDER | HEIGHT OF OVERFLOW ABOVE INNER BOTTOM METRES | | | | | | |
|---|---|---|---|---|---|---|---|
| | 6,0 | 7,5 | 9,0 | 10,5 | 12,0 | 13,5 | 15,0 |
| Millimetres | Millimetres *Modulus—Centimetres³* | | | | | | |
| 900 | 90×75× 7,5 *21,6* | 90×75× 9,5 *27,4* | 100×75× 8,5 *31,0* | 100×75×10,5 *36,5* | 100×75×11,5 *40,5* | 120×75× 9,5 *46,8* | 120×75×10,5 *51,5* |
| 1100 | 100×75× 9,5 *33,3* | 120×75× 8,0 *40,3* | 120×75× 9,5 *47,0* | 130×75× 9,5 *55,0* | 140×75× 9,5 *63,0* | 140×75×10,5 *70,5* | 150×75×10,5 *79,2* |
| 1300 | 120×75× 9,5 *48,1* | 130×75×10,5 *58,7* | 140×75×10,5 *68,6* | 150×75×11,0 *82,0* | *90,0* | 150×75× 8,0 *104* | 150×75× 9,0 *113* |
| 1500 | 140×75× 9,5 *61,9* | 150×75×10,5 *78,0* | *91,0* | 150×75× 8,5 *111* | 150×75×10,0 *121* | 165×75× 8,5 *133* | 165×75×10,0 *146* |
| 1700 | 150×75×11,0 *83,0* | *97,5* | 150×75× 9,5 *118* | 165×75× 9,0 *140* | 165×75×10,5 *155* | 180×75× 9,5 *175* | 180×75×11,0 *194* |
| 1900 | *100* | 150×75×10,5 *126* | 165×75×10,0 *147* | 180×75× 9,0 *172* | 180×75×11,0 *190* | 200×75× 9,0 *210* | 200×75×10,5 *239* |

ANGLES (900, 1100, 1300, 1500, 1700) — BULB ANGLES (1900)

ANGLES (900, 1100) — BULB ANGLES (1300, 1500, 1700, 1900)

### NOTES.—TABLE 9

1. **In boiler rooms** stiffeners are to be increased by 2,5 mm. in thickness.

2. Particulars of sections and moduli are given in Table 56.

### NOTES.—TABLE 10

1. **Scantlings.**—The bottom longitudinals are to have scantlings determined from the Table; the modulus of the inner bottom longitudinals may be 85 per cent of that of the bottom longitudinals corrected as required below. For width of faying flanges *see* D 3202.

2. **Corrections to modulus of bottom longitudinals.**

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than $d_b$, modulus to be $\frac{\text{increased}}{\text{reduced}}$ by the percentage given in the Table per 0,3 metre of difference.

FOR SPACING OF LONGITUDINALS.

If the spacing amidships differs from that given in the Table, modulus to be modified in direct proportion.

3. **In boiler rooms,** longitudinals, struts and angle connections are to be increased by 2,5 mm. in thickness.

4. Particulars of sections and moduli are given in Table 56.

# BOTTOM LONGITUDINALS — TABLE 10

| LENGTH L | SPACING OF LONGITUDINALS | BASIC DRAUGHT $d_b$ | *CORRECTION TO MODULUS PER 0,3 METRE DIFFERENCE BETWEEN d and $d_b$* | UNSUPPORTED SPAN METRES | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | **1,25** | **1,5** | **1,75** | **2,0** | **2,25** | **2,5** |
| Metres | Millimetres | Metres | Per cent | MILLIMETRES *Modulus—Centimetres³* | | | | | |
| **30** | 665 | 1,80 | *16,9* | 100×75×10 *35,6* | 120×75×8,5 *42,4* | 130×75× 8 *46,4* | 140×75× 8 *53,4* | 140×75× 9 *59,6* | 150×75× 9 *67,7* |
| **35** | 675 | 2,10 | *14,6* | 120×75× 8,5 *42,4* | 130×75× 8,5 *49,2* | 140×75× 8,5 *56,5* | 140×75× 9,5 *62,7* | 150×75× 9,5 *71,3* | 150×75×10,5 *78,5* |
| **40** | 685 | 2,40 | *12,8* | 130×75× 8,5 *49,2* | 140×75× 8,5 *56,5* | 140×75×10 *65,8* | 150×75×10 *74,9* | 150×75×11 *82,0* | 150×75× 7 *97* |
| **45** | 695 | 2,70 | *11,3* | 130×75× 9,5 *54,7* | 140×75× 9,5 *62,7* | 150×75×10 *74,9* | 150×75×11 *82,0* | 150×75× 7 *97* | 150×75× 8 *105* |
| **50** | 705 | 3,0 | *10,2* | 130×75×10,5 *59* | 140×75×10,5 *70* | 150×75×11 *81* | *92* | 150×75× 8 *103* | 150×75× 9 *115* |
| **55** | 715 | 3,3 | *9,2* | 140×75×10 *66* | 150×75×10,5 *79* | *92* | 150×75× 8 *104* | 150×75× 9,5 *116* | 165×75× 8 *129* |
| **60** | 725 | 3,6 | *8,4* | 150×75×10 *75* | *89* | 150×75× 8 *103* | 150×75× 9,5 *116* | 165×75× 8 *130* | 165×75× 9,5 *144* |
| **65** | 735 | 3,9 | *7,8* | 150×75×11,5 *84* | *99* | 150×75× 9 *114* | 165×75× 8 *129* | 165×75× 9,5 *144* | 180×75× 8 *160* |
| **70** | 745 | 4,2 | *7,2* | *93* | 150×75× 8,5 *109* | 150×75×10,5 *129* | 165×75× 9,5 *142* | 180×75× 8 *159* | 180×75× 9,5 *176* |
| **75** | 755 | 4,5 | *6,65* | 150×75× 8 *103* | 150×75×10 *121* | 165×75× 9 *139* | 180×75× 8 *156* | 180×75× 9,5 *175* | 180×75×11 *194* |
| **80** | 765 | 4,8 | *6,25* | 150×75× 9 *112* | 165×75× 8,5 *132* | 165×75×10,5 *151* | 180×75× 9 *171* | 180×75×11 *191* | 200×75× 9 *211* |
| **85** | 775 | 5,1 | *5,90* | 150×75×10 *122* | 165×75× 9,5 *145* | 180×75× 8,5 *164* | 180×75×10,5 *185* | *207* | 200×75×10 *230* |
| **90** | 785 | 5,4 | *5,60* | 165×75× 8,5 *134* | 180×90× 8 *157* | 180×90×10 *178* | 180×90×11,5 *200* | 200×90×10 *223* | 200×90×11,5 *248* |
| **95** | 795 | 5,7 | *5,30* | 165×75× 9,5 *145* | 180×90× 9 *170* | 180×90×11 *192* | *217* | 200×90×11 *241* | 200×90×12,5 *266* |
| **100** | 805 | 6,0 | *5,0* | 180×90× 8 *158* | 180×90×10,5 *184* | *208* | 200×90×10,5 *233* | 200×90×12 *259* | *286* |
| **105** | 815 | 6,3 | *4,57* | 180×90× 9,5 *173* | 180×90×11,5 *199* | 200×90×10 *224* | 200×90×11,5 *250* | *277* | *306* |
| **110** | 825 | 6,6 | *4,50* | 180×90×10,5 *187* | *212* | *242* | *269* | *296* | 230×90×11,5 *326* |
| **115** | 835 | 6,9 | *4,35* | 180×90×11,5 *199* | 200×90×10 *229* | 200×90×12 *258* | *287* | *317* | 230×90×12,5 *349* |
| **120** | 845 | 7,2 | *4,20* | *214* | 200×90×11,5 *245* | *276* | *307* | 230×90×12 *339* | *371* |
| **125** | 855 | 7,5 | *4,05* | 200×90×10 *230* | 200×90×12,5 *261* | *294* | 230×90×11 *327* | 230×90×13 *361* | *396* |
| **130** | 865 | 7,8 | *3,85* | 200×90×11,5 *247* | *278* | *312* | 230×90×12,5 *348* | *384* | 250×90×12 *419* |
| **135** | 875 | 8,1 | *3,70* | 200×90×12,5 *265* | *297* | 230×90×11,5 *333* | *371* | 250×90×11 *407* | 250×90×13 *442* |
| **140** | 885 | 8,4 | *3,55* | *281* | *318* | 230×90×12,5 *352* | *390* | 250×90×12,5 *430* | *470* |
| **145** | 895 | 8,7 | *3,40* | *302* | 230×90×11,5 *337* | *376* | 250×90×11,5 *416* | 250×90×13,5 *456* | *496* |
| **150** | 905 | 9,0 | *3,30* | *321* | 230×90×13 *358* | 250×90×11 *399* | 250×90×12,5 *439* | *480* | *522* |

ANGLES — BULB ANGLES

*For notes see previous page*

# TABLE 11

(SEE CONTINUATION)

## ATTACHMENT OF TANK SIDE BRACKETS

| DEPTH D | FRAME SPACING AMIDSHIPS | HEIGHT OF TANK SIDE BRACKET ABOVE BASE | FRAME | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 90 AND 100 MM. ORDINARY ANGLE | | | | 120 AND 130 MM. ORDINARY ANGLE | | | | 150 MM. ORDINARY ANGLE | | | |
| | | | THICKNESS OF TANK SIDE BRACKET AND GUSSET | NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE | | | THICKNESS OF TANK SIDE BRACKET AND GUSSET | NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE | | | THICKNESS OF TANK SIDE BRACKET AND GUSSET | NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE | | |
| | | | | ANGLE TO MARGIN | GUSSET | FRAME CONNECTION | | ANGLE TO MARGIN | GUSSET | FRAME CONNECTION | | ANGLE TO MARGIN | GUSSET | FRAME CONNECTION |
| Metres | Millimetres | Millimetres | Millimetres | | | | Millimetres | | | | Millimetres | | | |
| 4 | 552 | 870 | 7 | 5† | — | 5† | 7,5 | 5* | — | 5† | 7,5 | 5* | — | 5† |
| 5 | 573 | 1040 | 7 | 5* | — | 5† | 7,5 | 5* | — | 5* | 8 | 5* | — | 5* |
| 6 | 595 | 1205 | | | | | | | | | 8,5 | 6* | — | 5* |
| 7 | 620 | 1360 | | | | | | | | | | | | |
| 8 | 662 | 1485 | | | | | | | | | | | | |
| 9 | 705 | 1610 | | | | | | | | | | | | |
| 10 | 748 | 1730 | | | | | | | | | | | | |
| 11 | 790 | 1830 | | | | | | | | | | | | |
| 12 | 830 | 1910 | | | | | | | | | | | | |
| 13 | 870 | 1985 | | | | | | | | | | | | |
| 14 | 912 | 2055 | | | | | | | | | | | | |
| 15 | 955 | 2120 | | | | | | | | | | | | |

† Rivets 16 mm. diameter * Rivets 19 mm. diameter Remainder 22 mm. diameter.

*For notes see pages 94 & 95*

## TO MARGIN PLATE AND FRAMES

TABLE 11
*(SEE CONTINUATION)*

| FRAME | | | | | | | | | | | | | | | DEPTH D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 AND 165 MM. BULB ANGLE | | | | 180 MM. BULB ANGLE | | | | 200 MM. BULB ANGLE | | | | 230 MM. BULB ANGLE | | | | |
| THICKNESS OF TANK SIDE BRACKET AND GUSSET | NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE | | | THICKNESS OF TANK SIDE BRACKET AND GUSSET | NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE | | | THICKNESS OF TANK SIDE BRACKET AND GUSSET | NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE | | | THICKNESS OF TANK SIDE BRACKET AND GUSSET | NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE | | | |
| | ANGLE TO MARGIN | GUSSET | FRAME CONNECTION | | ANGLE TO MARGIN | GUSSET | FRAME CONNECTION | | ANGLE TO MARGIN | GUSSET | FRAME CONNECTION | | ANGLE TO MARGIN | GUSSET | FRAME CONNECTION | |
| Millimetres | | | | Millimetres | | | | Millimetres | | | | Millimetres | | | | Metres |
| 8 | 6* | — | 5* | | | | | | | | | | | | | 4 |
| 8 | 6* | — | 6* | | | | | | | | | | | | | 5 |
| 8,5 | 6* | — | 6* | 8,5 | 6* | 1* | 6* | 8,5 | 6* | 2* | 7* | | | | | 6 |
| 9 | 6* | 1* | 6* | 9 | 6* | 2* | 6* | 9 | 5 | 2 | 6 | 9,5 | 6 | 3 | 7 | 7 |
| 9,5 | 6* | 2* | 6* | 9,5 | 5 | 1 | 5 | 9,5 | 5 | 2 | 6 | 10 | 6 | 4 | 8 | 8 |
| | | | | 10,5 | 6 | 2 | 6 | 10,5 | 6 | 3 | 7 | 10,5 | 7 | 4 | 8 | 9 |
| | | | | | | | | 10,5 | 7 | 3 | 7 | 11 | 8 | 4 | 8 | 10 |
| | | | | | | | | 11 | 7 | 4 | 8 | 11 | 8 | 5 | 8 | 11 |
| | | | | | | | | | | | | 11,5 | 8 | 6 | 9 | 12 |
| | | | | | | | | | | | | 12 | 8 | 7 | 9 | 13 |
| | | | | | | | | | | | | 12 | 8 | 7 | 9 | 14 |
| | | | | | | | | | | | | | | | | 15 |

† Rivets 16 mm. diameter * Rivets 19 mm. diameter Remainder 22 mm. diameter.

*For notes see pages 94 & 95*

## TABLE 11
(CONCLUDED)

## ATTACHMENT OF TANK SIDE BRACKETS

| DEPTH D | FRAME SPACING AMIDSHIPS | HEIGHT OF TANK SIDE BRACKET ABOVE BASE | FRAME | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 250 MM. BULB ANGLE | | | | 280 MM. BULB ANGLE | | | | 300 MM. BULB ANGLE | | | |
| | | | THICKNESS OF TANK SIDE BRACKET AND GUSSET | NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE | | | THICKNESS OF TANK SIDE BRACKET AND GUSSET | NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE | | | THICKNESS OF TANK SIDE BRACKET AND GUSSET | NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE | | |
| | | | | ANGLE TO MARGIN | GUSSET | FRAME CONNECTION | | ANGLE TO MARGIN | GUSSET | FRAME CONNECTION | | ANGLE TO MARGIN | GUSSET | FRAME CONNECTION |
| Metres | Millimetres | Millimetres | Millimetres | | | | Millimetres | | | | Millimetres | | | |
| **4** | 552 | 870 | | | | | | | | | | | | |
| **5** | 573 | 1040 | | | | | | | | | | | | |
| **6** | 595 | 1205 | | | | | | | | | | | | |
| **7** | 620 | 1360 | 10 | 6 | 5 | 8 | | | | | | | | |
| **8** | 662 | 1485 | 10,5 | 7 | 6 | 8 | 10,5 | 7 | 6 | 8 | 10,5 | 8 | 8 | 9 |
| **9** | 705 | 1610 | 11 | 8 | 6 | 9 | 11 | 8 | 7 | 9 | 11 | 9 | 8 | 10 |
| **10** | 748 | 1730 | 11 | 8 | 6 | 9 | 11 | 8 | 7 | 9 | 11,5 | 9 | 8 | 10 |
| **11** | 790 | 1830 | 11,5 | 8 | 6 | 9 | 11,5 | 9 | 7 | 10 | 12 | 9 | 8 | 10 |
| **12** | 830 | 1910 | 12 | 8 | 7 | 10 | 12 | 9 | 8 | 11 | 12 | 9 | 9 | 11 |
| **13** | 870 | 1985 | 12 | 8 | 8 | 10 | 12 | 9 | 9 | 11 | 12,5 | 10 | 9 | 11 |
| **14** | 912 | 2055 | 12 | 9 | 8 | 10 | 12,5 | 9 | 9 | 11 | 12,5 | 10 | 9 | 12 |
| **15** | 955 | 2120 | 12,5 | 9 | 8 | 10 | 12,5 | 10 | 9 | 11 | 12,5 | 11 | 9 | 12 |

Rivets 22 mm. diameter.

### NOTES.—TABLE 11

1. **Corrections.**—If the frame spacing amidships is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than that given in the Table, the thickness of the tank side brackets is to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ at the rate of 0,5 mm. for every 100 mm. of difference.

2. The height of tank side brackets is to be measured at the inner edge of the frame.

TABLE 11
(CONCLUDED)

| FRAME | | | | | | | | | | | | DEPTH D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 300 TO 350 MM. CHANNEL AND 320 TO 340 MM. BULB ANGLE | | | | 380 MM. CHANNEL OR BULB ANGLE | | | | 400 MM. CHANNEL | | | | |
| THICKNESS OF TANK SIDE BRACKET AND GUSSET | NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE | | | THICKNESS OF TANK SIDE BRACKET AND GUSSET | NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE | | | THICKNESS OF TANK SIDE BRACKET AND GUSSET | NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE | | | |
| | ANGLE TO MARGIN | GUSSET | FRAME CONNECTION | | ANGLE TO MARGIN | GUSSET | FRAME CONNECTION | | ANGLE TO MARGIN | GUSSET | FRAME CONNECTION | |
| Millimetres | | | | Millimetres | | | | Millimetres | | | | Metres |
| | | | | | | | | | | | | 4 |
| | | | | | | | | | | | | 5 |
| | | | | | | | | | | | | 6 |
| | | | | | | | | | | | | 7 |
| 11 | 9 | 8 | 10 | 11 | 9 | 9 | 12 | 11,5 | 10 | 9 | 13 | 8 |
| 11 | 10 | 8 | 10 | 11,5 | 10 | 9 | 12 | 12 | 11 | 9 | 13 | 9 |
| 11,5 | 10 | 8 | 11 | 11,5 | 10 | 9 | 12 | 12 | 11 | 9 | 13 | 10 |
| 12 | 10 | 8 | 11 | 12 | 10 | 9 | 12 | 12,5 | 11 | 10 | 13 | 11 |
| 12,5 | 10 | 9 | 11 | 12,5 | 11 | 10 | 12 | 13 | 12 | 11 | 14 | 12 |
| 13 | 11 | 9 | 12 | 13 | 11 | 10 | 13 | 13 | 12 | 11 | 14 | 13 |
| 13 | 11 | 9 | 12 | 13 | 12 | 10 | 13 | 13 | 13 | 11 | 14 | 14 |
| 13 | 12 | 10 | 12 | 13 | 13 | 11 | 13 | 13 | 14 | 12 | 14 | 15 |

Rivets 22 mm. diameter.

**NOTES.—TABLE 11** (*continued*)

3. The angles connecting the tank side brackets to the margin plate are to have the same thickness as the brackets.

4. **In boiler rooms**, the tank side brackets, gussets and connecting angles are to be increased 2,5 mm. in thickness.

5. For increases in way of panting region *see* D 906.

# TABLE 12
(SEE CONTINUATION)

## MAIN FRAMING

| DEPTH D | FRAME SPACING AMIDSHIPS | BASIC DRAUGHT $d_b$ | FRAMING IN PEAKS | Correction to Modulus of Main Framing per 0,3 metre difference between d and $d_b$ | DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — METRES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 2,4 | 3,0 | 3,6 | 3,9 | 4,2 | 4,5 | 4,8 | 5,1 | 5,4 |
| Metres | Mm. | Metres | Millimetres *Modulus—cms.*³ | Per cent | < Millimetres *Modulus—centimetres*³ > | | | | | | | | |
| 3,0 | 535 | 2,35 | 90×65× 8 *24,0* | *14,9* | 90×75× 7 *21,0* | 90×75× 8 *24,0* | 90×75× 9,5 *28,0* | 100×75× 8,5 *31,0* | 100×75× 9,5 *34,0* | | | | |
| 3,3 | 540 | 2,60 | 90×65× 9,5 *28,0* | *13,9* | 90×75× 8 *23,0* | 90×75× 9,5 *28,0* | 100×75× 9,5 *34,0* | 100×75×10,5 *37,0* | 120×75× 8 *41,0* | | | | |
| 3,6 | 545 | 2,85 | 100×75× 8,5 *30,0* | *12,9* | 90×75× 8,5 *25,0* | 100×75× 9 *32,0* | 120×75× 8 *40,0* | 120×75× 9 *44,0* | 130×75× 8,5 *49,0* | 130×75×10 *56,0* | | | |
| 3,9 | 550 | 3,10 | 100×75×11,5 *40,0* | *12,0* | | | 130×75× 8 *47,0* | 130×75× 9 *52,0* | 130×75×10 *58,0* | 150×75× 9 *65,0* | 150×75×10 *73,0* | | |
| 4,2 | 555 | 3,35 | 130×75× 9,5 *54,0* | *11,1* | | | 130×75× 9,5 *55,0* | 150×75× 8,5 *62,0* | 150×75× 9,5 *68,0* | 150×75×10,5 *76,0* | 150×75×11,5 *84,0* | 150×75×12,5 *93,0* | |
| 4,5 | 565 | 3,60 | 130×75×10 *58,0* | *10,5* | | | 150×75× 8,5 *63,0* | 150×75× 9,5 *71,0* | 150×85×10,5 *78,0* | 150×75×12 *87,0* | 140×65× 9 *95,0* | 150×75× 8 *104* | 150×75× 9 *114* |
| 4,8 | 570 | 3,85 | 130×75×11 *62,0* | *10,0* | | | | 150×75×11 *81,0* | 150×75×12 *89,0* | 150×75× 7,5 *98,0* | 150×75× 8,5 *107* | 150×75× 9,5 *118* | 150×75×10,5 *128* |
| 5,1 | 575 | 4,10 | 150×75× 9 *66,0* | *9,5* | | | | | 150×75× 8 *102* | 150×75× 9 *112* | 150×75×10 *121* | 165×75× 8,5 *132* | 165×75× 9,5 *144* |
| 5,4 | 580 | 4,35 | 150×75× 9,5 *70,0* | *9,0* | | | | | 150×75× 9,5 *115* | 150×75×10,5 *126* | 165×75× 9 *136* | 165×75×10 *148* | 180×75× 8,5 *161* |
| 5,7 | 590 | 4,55 | 150×75×10 *75,0* | *8,5* | 150×75× 7,5 *101* | 150×75× 8,5 *106* | 150×75× 9,5 *115* | 150×75×10 *121* | 165×75× 8,5 *130* | 165×75× 9,5 *140* | 165×75×10,5 *151* | 180×75× 9 *166* | 180×75×10 *182* |
| 6,0 | 595 | 4,75 | 150×75×11 *82,0* | *8,0* | 150×75× 8,5 *108* | 150×75× 9,5 *115* | 150×75×10,5 *126* | 165×75× 9 *134* | 165×75×10 *145* | 180×75× 8 *157* | 180×75× 9,5 *171* | 180×75×10,5 *187* | *205* |
| 6,3 | 600 | 5,00 | 140×65× 8 *88,0* | *7,5* | 150×75× 9,5 *118* | 150×75×10,5 *125* | 165×75× 9 *138* | 165×75×10 *147* | 180×75× 8 *158* | 180×75× 9,5 *173* | 180×75×10,5 *188* | *205* | 200×75×10 *224* |
| 6,6 | 605 | 5,25 | 140×65× 9 *96,0* | *7,0* | 150×75×10,5 *127* | 165×75× 9 *136* | 165×75×10,5 *150* | 180×75× 8 *159* | 180×75× 9,5 *172* | 180×75×10,5 *187* | *203* | 200×75× 9,5 *220* | 200×75×11 *240* |
| 6,9 | 615 | 5,50 | 150×75× 8 *105* | *6,6* | 165×75× 9 *137* | 165×75×10 *147* | 180×75× 8,5 *162* | 180×75× 9,5 *172* | 180×75×10,5 *185* | *200* | 200×75× 9,5 *217* | 200×75×10,5 *235* | 200×75×12 *255* |
| 7,2 | 630 | 5,75 | 150×75× 9 *115* | *6,3* | 165×75×10 *148* | 180×75× 8 *158* | 180×75× 9,5 *174* | 180×75×10,5 *186* | *200* | 200×75× 9 *215* | 200×75×10,5 *232* | 200×75×12 *252* | *274* |
| 7,5 | 645 | 6,00 | 150×75×10 *125* | *6,0* | 180×75× 8 *160* | 180×75× 9 *170* | 180×75×10,5 *187* | *199* | 200×75× 9 *215* | 200×75×10 *230* | 200×75×11,5 *248* | 200×90×13 *268* | *290* |
| 7,8 | 655 | 6,25 | 165×75× 9 *135* | *5,8* | 180×75× 9,5 *172* | 180×75×10,5 *182* | *201* | 200×75× 9 *214* | 200×75×10 *230* | 200×75×11,5 *246* | 200×90×12,5 *264* | *285* | *310* |
| 8,1 | 665 | 6,50 | 165×75×10 *146* | *5,6* | 180×75×10,5 *187* | *197* | 200×75× 9 *216* | 200×75×10 *229* | 200×75×11 *245* | 200×90×12,5 *263* | *282* | *304* | 230×90×11,5 *330* |
| 8,4 | 680 | 6,75 | 180×75× 8 *157* | *5,4* | *202* | 200×75× 9 *212* | 200×75×10 *231* | 200×75×11 *245* | 200×75×12 *260* | *280* | *300* | 230×90×11 *324* | 230×90×12,5 *351* |
| 8,7 | 695 | 6,95 | 180×75× 9 *169* | *5,2* | 200×75× 9 *218* | 200×75×10 *228* | 200×75×11,5 *247* | 200×90×12,5 *262* | *277* | *298* | 230×90×11 *320* | 230×90×12,5 *346* | *374* |
| 9,0 | 705 | 7,15 | 180×75×10,5 *183* | *5,0* | 200×75×10,5 *236* | 200×75×11,5 *246* | 200×90×13 *265* | *280* | *297* | 230×90×11 *318* | 230×90×12 *341* | *368* | 250×90×11 *399* |

ANGLES — BULB ANGLES

*For notes see page 101*

| DEPTH D | FRAME SPACING AMIDSHIPS | BASIC DRAUGHT $d_b$ | *Correction to Modulus of Main Framing per 0,3 metre difference between d and $d_b$* | | DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — METRES | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 5,7 | 6,0 | 6,3 | 6,6 | 6,9 | 7,2 | 7,5 | 7,8 |
| Metres | Mm. | Metres | Per cent | | Millimetres — *Modulus—centimetres³* | | | | | | | |
| 3,0 | 535 | 2,35 | *14,9* | ANGLES | | | | | | | | |
| 3,3 | 540 | 2,60 | *13,9* | ANGLES | | | | | | | | |
| 3,6 | 545 | 2,85 | *12,9* | ANGLES | | | | | | | | |
| 3,9 | 550 | 3,10 | *12,0* | ANGLES | | | | | | | | |
| 4,2 | 555 | 3,35 | *11,1* | ANGLES | | | | | | | | |
| 4,5 | 565 | 3,60 | *10,5* | BULB ANGLES | | | | | | | | |
| 4,8 | 570 | 3,85 | *10,0* | BULB ANGLES | 165×75× 9<br>*139* | | | | | | | |
| 5,1 | 575 | 4,10 | *9,5* | BULB ANGLES | 180×75× 8<br>*156* | 180×75× 9<br>*170* | | | | | | |
| 5,4 | 580 | 4,35 | *9,0* | BULB ANGLES | 180×75× 9,5<br>*175* | 180×75×11<br>*192* | 200×75× 9<br>*210* | | | | | |
| 5,7 | 590 | 4,55 | *8,5* | BULB ANGLES | *198* | 200×75× 9,5<br>*216* | 200×75×10,5<br>*235* | 200×75×12<br>*255* | | | | |
| 6,0 | 595 | 4,75 | *8,0* | BULB ANGLES | 200×75× 9,5<br>*222* | 200×75×11<br>*242* | 200×90×13<br>*264* | *285* | *307* | | | |
| 6,3 | 600 | 5,00 | *7,5* | BULB ANGLES | 200×75×11<br>*242* | 200×90×13<br>*264* | *286* | *309* | 230×90×11<br>*334* | 230×90×13<br>*358* | | |
| 6,6 | 605 | 5,25 | *7,0* | BULB ANGLES | 200×90×12,5<br>*260* | *282* | *306* | 230×90×11,5<br>*330* | 230×90×13<br>*357* | *382* | 250×90×11,5<br>*410* | |
| 6,9 | 615 | 5,50 | *6,6* | BULB ANGLES | *277* | *301* | 230×90×11<br>*327* | 230×90×12,5<br>*354* | *383* | 250×90×11,5<br>*411* | 250×90×13<br>*440* | *470* |
| 7,2 | 630 | 5,75 | *6,3* | BULB ANGLES | *296* | 230×90×11<br>*321* | 230×90×12,5<br>*350* | *378* | 250×90×11,5<br>*409* | 250×90×12,5<br>*438* | *470* | *504* |
| 7,5 | 645 | 6,00 | *6,0* | BULB ANGLES | *315* | 230×90×12<br>*342* | *371* | *402* | 250×90×12,5<br>*434* | 250×90×14<br>*465* | *500* | *535* |
| 7 8 | 655 | 6,25 | *5,8* | BULB ANGLES | 230×90×11,5<br>*334* | 230×90×13<br>*364* | *395* | 250×90×12<br>*428* | 250×90×14<br>*462* | *495* | *531* | 280×90×13,5<br>*569* |
| 8,1 | 665 | 6,50 | *5,6* | BULB ANGLES | 230×90×13<br>*357* | *387* | 250×90×12<br>*422* | 250×90×13,5<br>*455* | *492* | *525* | 280×90×13<br>*563* | 280×90×14,5<br>*604* |
| 8,4 | 680 | 6,75 | *5,4* | BULB ANGLES | *380* | 250×90×11,5<br>*414* | 250×90×13<br>*448* | *484* | *522* | 280×90×12,5<br>*556* | 280×90×14,5<br>*597* | *640* |
| 8,7 | 695 | 6,95 | *5,2* | BULB ANGLES | 250×90×11<br>*405* | 250×90×13<br>*440* | *475* | *512* | 280×90×12,5<br>*552* | 280×90×14<br>*591* | *633* | 300×90×13,5<br>*677* |
| 9,0 | 705 | 7,15 | *5,0* | BULB ANGLES | 250×90×12,5<br>*430* | 250×90×14<br>*465* | *504* | 280×90×12<br>*542* | 280×90×14<br>*585* | *625* | 300×90×13<br>*670* | 300×90×15<br>*717* |

*For notes see page 101*

# TABLE 12
(SEE CONTINUATION)

## MAIN FRAMING

| DEPTH D | FRAME SPACING AMIDSHIPS | BASIC DRAUGHT $d_b$ | Correction to Modulus of Main Framing per 0,3 metre difference between d and $d_b$ | | DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — METRES | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 8,1 | 8,4 | 8,7 | 9,0 | 9,3 | 9,6 | 9,9 | 10,2 |
| Metres | Mm. | Metres | Per cent | | Millimetres — *Modulus—centimetres³* | | | | | | | |
| 3,0 | 535 | 2,35 | *14,9* | ANGLES | | | | | | | | |
| 3,3 | 540 | 2,60 | *13,9* | ANGLES | | | | | | | | |
| 3,6 | 545 | 2,85 | *12,9* | ANGLES | | | | | | | | |
| 3,9 | 550 | 3,10 | *12,0* | ANGLES | | | | | | | | |
| 4,2 | 555 | 3,35 | *11,1* | ANGLES | | | | | | | | |
| 4,5 | 565 | 3,60 | *10,5* | BULB ANGLES | | | | | | | | |
| 4,8 | 570 | 3,85 | *10,0* | BULB ANGLES | | | | | | | | |
| 5,1 | 575 | 4,10 | *9,5* | BULB ANGLES | | | | | | | | |
| 5,4 | 580 | 4,35 | *9,0* | BULB ANGLES | | | | | | | | |
| 5,7 | 590 | 4,55 | *8,5* | BULB ANGLES | | | | | | | | |
| 6,0 | 595 | 4,75 | *8,0* | BULB ANGLES | | | | | | | | |
| 6,3 | 600 | 5,00 | *7,5* | BULB ANGLES | | | | | | | | |
| 6,6 | 605 | 5,25 | *7,0* | BULB ANGLES | | | | | | | | |
| 6,9 | 615 | 5,50 | *6,6* | BULB ANGLES | | | | | | | | |
| 7,2 | 630 | 5,75 | *6,3* | BULB ANGLES | 280×90×12 *539* | | | | | | | |
| 7,5 | 645 | 6,00 | *6,0* | BULB ANGLES | 280×90×13,5 *572* | 280×90×14,5 *610* | | | | | | |
| 7,8 | 655 | 6,25 | *5,8* | BULB ANGLES | 280×90×14,5 *608* | *647* | 300×90×13,5 *685* | 300×90×15 *726* | | | | |
| 8,1 | 665 | 6,50 | *5,6* | BULB ANGLES | *645* | 300×90×13,5 *685* | 300×90×15 *727* | 300×100×100×13 *769* | 300×100×100×14,5 *813* | | | |
| 8,4 | 680 | 6,75 | *5,4* | BULB ANGLES | 300×90×13,5 *684* | 300×90×15 *727* | 300×100×100×13 *772* | 300×100×100×14,5 *817* | 300×100×100×16,5 *863* | 320×100×100×14,5 *909* | | |
| 8,7 | 695 | 6,95 | *5,2* | BULB ANGLES | 300×90×15 *724* | 300×100×100×13 *771* | 300×100×100×14,5 *817* | 300×100×100×16,5 *864* | 320×100×100×14,5 *911* | *959* | 350×100×100×15 *1006* | |
| 9,0 | 705 | 7,15 | *5,0* | CHL. | *765* | 300×100×100×14,5 *814* | 300×100×100×16,5 *863* | 380×100×100×14,5 *913* | *964* | *1014* | 381×100×100×13 *1065* | 381×100×100×14 *1114* |

*For notes see page 101*

| DEPTH D | FRAME SPACING AMIDSHIPS | BASIC DRAUGHT $d_b$ | FRAMING IN PEAKS | Correction to Modulus of Main Framing per 0,3 metre difference between d and $d_b$ | DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — METRES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 2,4 | 3,0 | 3,6 | 3,9 | 4,2 | 4,5 | 4,8 | 5,1 | 5,4 |
| Metres | Mm. | Metres | Millimetres *Modulus—cms.*³ | Per cent | < Millimetres *Modulus—centimetres*³ > | | | | | | | | |
| 9,3 | 715 | 7,40 | *197* | *4,8* | 200×90×11,5 *252* | 200×90×12,5 *263* | *283* | *298* | 230×90×11 *315* | 230×90×12 *337* | 230×90×13 *362* | *390* | 250×90×12 *422* |
| 9,6 | 730 | 7,65 | 200×75×9 *214* | *4,6* | 200×90×13 *273* | *282* | *302* | 230×90×11 *317* | 230×90×11,5 *335* | 230×90×13 *357* | *383* | 250×90×11,5 *414* | 250×90×13 *447* |
| 9,9 | 745 | 7,90 | 200×75×10,5 *232* | *4,4* | *290* | *300* | 230×90×11 *321* | 230×90×12 *337* | 230×90×13 *355* | *378* | 250×90×11 *404* | 250×90×12,5 *436* | 250×90×14 *470* |
| 10,2 | 755 | 8,15 | 200×75×11,5 *250* | *4,3* | *309* | *319* | 230×90×12 *341* | 230×90×13 *357* | *376* | 250×90×11 *401* | 250×90×12,5 *427* | 250×90×14 *459* | *496* |
| 10,5 | 765 | 8,40 | *276* | *4,2* | 230×90×11 *328* | 230×90×12 *339* | 230×90×13 *361* | *378* | 250×90×11 *398* | 250×90×12 *423* | 250×90×13,5 *451* | *484* | *522* |
| 10,8 | 780 | 8,65 | *301* | *4,1* | 230×90×12,5 *348* | 230×90×13 *360* | *382* | 250×90×11 *400* | 250×90×12 *420* | 250×90×13 *445* | *474* | *509* | 280×90×12 *548* |
| 11,1 | 795 | 8,85 | 230×90×11 *327* | *4,0* | *367* | *379* | 250×90×11 *403* | 250×90×12 *420* | 250×90×13 *442* | 250×90×14 *467* | *496* | 280×90×12 *530* | 280×90×13,5 *570* |
| 11,4 | 805 | 9,00 | 230×90×12 *345* | *3,9* | *385* | *398* | 250×90×12 *421* | 250×90×13 *439* | 250×90×14 *460* | *486* | *516* | 280×90×12,5 *552* | 280×90×14 *594* |
| 11,7 | 815 | 9,15 | *349* | *3,9* | *398* | 250×90×11,5 *411* | 250×90×12,5 *435* | 250×90×13,5 *454* | *475* | *504* | 280×90×12 *534* | 280×90×13,5 *569* | *612* |
| 12,0 | 830 | 9,15 | 230×90×12,5 *352* | *3,9* | 250×90×11,5 *411* | 250×90×12 *425* | 250×90×13,5 *450* | *469* | *490* | *519* | 280×90×12,5 *549* | 280×90×14 *587* | *630* |
| 12,3 | 845 | 9,15 | *355* | *3,9* | 250×90×12 *423* | 250×90×13 *438* | 250×90×14 *464* | *483* | *505* | *533* | 280×90×13 *565* | 280×90×14,5 *604* | *648* |
| 12,6 | 855 | 9,15 | 230×90×13 *358* | *3,9* | 250×90×12,5 *435* | 250×90×13,5 *450* | *478* | *498* | *520* | 280×90×12,5 *548* | 280×90×13,5 *580* | *620* | 300×90×13 *665* |
| 12,9 | 865 | 9,15 | *362* | *3,9* | 250×90×13 *448* | 250×90×14 *464* | *492* | *512* | 280×90×12 *535* | 280×90×13 *564* | 280×90×14,5 *596* | *636* | 300×90×13,5 *682* |
| 13,2 | 880 | 9,15 | *365* | *3,9* | 250×90×13,5 *459* | *476* | *506* | *527* | 280×90×12,5 *550* | 280×90×13,5 *580* | *613* | *654* | 300×90×14 *701* |
| 13,5 | 895 | 9,15 | *368* | *3,9* | *471* | *490* | *521* | 280×90×12 *542* | 280×90×13 *565* | 280×90×14 *595* | *629* | 300×90×13 *670* | 300×90×15 *718* |
| 13,8 | 905 | 9,15 | *371* | *3,9* | *483* | *502* | 280×90×12 *534* | 280×90×12,5 *556* | 280×90×13,5 *580* | *610* | *645* | 300×90×13,5 *685* | 300×90×15,5 *734* |
| 14,1 | 915 | 9,15 | *374* | *3,9* | *494* | *513* | 280×90×12,5 *547* | 280×90×13 *569* | 280×90×14 *595* | *624* | 300×90×13 *658* | 300×90×14 *700* | 300×90×16 *749* |
| 14,4 | 930 | 9,15 | *377* | *3,9* | *508* | *528* | 280×90×13 *563* | 280×90×14 *586* | *611* | *641* | 300×90×13,5 *676* | 300×90×15 *720* | *769* |
| 14,7 | 945 | 9,15 | *381* | *3,9* | *521* | 280×90×12 *541* | 280×90×13,5 *577* | 280×90×14,5 *602* | *627* | *657* | 300×90×14 *693* | 300×90×15,5 *739* | 300×100×100×13,5 *788* |
| 15,0 | 955 | 9,15 | *384* | *3,9* | *533* | 280×90×12,5 *554* | 280×90×14 *590* | *615* | *641* | 300×90×13,5 *671* | 300×90×14,5 *707* | 300×90×16 *753* | 300×100×100×14 *805* |

BULB ANGLES

*For notes see page 101*

# TABLE 12

(SEE CONTINUATION)

## MAIN FRAMING

| DEPTH D | FRAME SPACING AMIDSHIPS | BASIC DRAUGHT $d_b$ | *Correction to Modulus of Main Framing per 0,3 metre difference between d and $d_b$* | DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — METRES | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **5,7** | **6,0** | **6,3** | **6,6** | **6,9** | **7,2** | **7,5** | **7,8** |
| Metres | Mm. | Metres | Per cent | Millimetres — *Modulus—centimetres³* | | | | | | | |
| **9,3** | 715 | 7,40 | *4,8* | 250×90×13,5 *455* | *493* | 280×90×12 *533* | 280×90×13,5 *572* | *617* | *659* | 300×90×14,5 *706* | *755* |
| **9,6** | 730 | 7,65 | *4,6* | *482* | *522* | 280×90×13 *564* | 280×90×14,5 *606* | *653* | 300×90×14 *698* | *747* | 300×100×100×14 *800* |
| **9,9** | 745 | 7,90 | *4,4* | *508* | 280×90×12,5 *549* | 280×90×14 *594* | *638* | 300×90×13,5 *685* | 300×90×15,5 *733* | 300×100×100×13,5 *785* | 300×100×100×15,5 *840* |
| **10,2** | 755 | 8,15 | *4,3* | 280×90×12 *535* | 280×90×13,5 *579* | *625* | 300×90×13,5 *672* | 300×90×15 *725* | 300×100×100×13 *775* | 300×100×100×15 *830* | 320×100×100×13,5 *885* |
| **10,5** | 765 | 8,40 | *4,2* | 280×90×13 *562* | 280×90×14,5 *609* | *657* | 300×90×14,5 *706* | *761* | 300×100×100×14,5 *815* | 300×100×100×17 *872* | 320×100×100×15,5 *934* |
| **10,8** | 780 | 8,65 | *4,1* | 280×90×14 *590* | *640* | 300×90×14 *691* | *744* | 300×100×100×14 *800* | 300×100×100×16 *855* | 320×100×100×15 *917* | *980* |
| **11,1** | 795 | 8,85 | *4,0* | *615* | 300×90×13 *669* | 300×90×15 *724* | 300×100×100×13 *779* | 300×100×100×15,5 *838* | 320×100×100×14 *895* | *958* | *1025* |
| **11,4** | 805 | 9,00 | *3,9* | *640* | 300×90×14 *695* | 300×90×16 *750* | 300×100×100×14,5 *808* | 300×100×100×16,5 *868* | 320×100×100×15,5 *928* | *994* | *1062* |
| **11,7** | 815 | 9,15 | *3,9* | 300×90×13 *660* | 300×90×14,5 *714* | 300×100×100×13 *771* | 300×100×100×15 *828* | 320×100×100×13,5 *889* | 320×100×100×16 *949* | *1015* | 381×100×100×13 *1082* |
| **12,0** | 830 | 9,15 | *3,9* | 300×90×13,5 *679* | 300×90×15,5 *733* | 300×100×100×13,5 *791* | 300×100×100×16 *850* | 320×100×100×14,5 *911* | *970* | *1036* | 381×100×100×13,5 *1104* |
| **12,3** | 845 | 9,15 | *3,9* | 300×90×14 *695* | 300×90×16 *752* | 300×100×100×14,5 *810* | 300×100×100×17 *870* | 320×100×100×15,5 *931* | *990* | *1056* | 381×100×100×14 *1125* |
| **12,6** | 855 | 9,15 | *3,9* | 300×90×14,5 *714* | 300×100×100×13 *770* | 300×100×100×15 *830* | 320×100×100×14 *890* | 320×100×100×16 *951* | *1010* | 381×100×100×13 *1077* | 381×100×100×15 *1147* |
| **12,9** | 865 | 9,15 | *3,9* | 300×90×15,5 *732* | 300×100×100×13,5 *790* | 300×100×100×16 *850* | 320×100×100×14,5 *910* | *972* | *1031* | 381×100×100×13,5 *1098* | 381×100×100×15,5 *1166* |
| **13,2** | 880 | 9,15 | *3,9* | 300×90×16 *751* | 300×100×100×14,5 *810* | 300×100×100×17 *870* | 320×100×100×15,5 *930* | *992* | *1052* | 381×100×100×14 *1119* | 381×100×100×16 *1186* |
| **13,5** | 895 | 9,15 | *3,9* | 300×100×100×13 *770* | 300×100×100×15 *830* | 320×100×100×14 *890* | 320×100×100×16 *950* | *1012* | 381×100×100×13 *1073* | 381×100×100×14,5 *1139* | 381×100×100×16,5 *1208* |
| **13,8** | 905 | 9,15 | *3,9* | 300×100×100×13,5 *787* | 300×100×100×16 *847* | 320×100×100×14,5 *908* | *969* | *1032* | 381×100×100×13,5 *1094* | 381×100×100×15 *1160* | 381×100×100×17 *1230* |
| **14,1** | 915 | 9,15 | *3,9* | 300×100×100×14 *802* | 300×100×100×16,5 *863* | 320×100×100×15 *925* | *987* | *1052* | 381×100×100×14 *1114* | 381×100×100×15,5 *1180* | 381×100×100×17,5 *1250* |
| **14,4** | 930 | 9,15 | *3,9* | 300×100×100×15 *824* | 320×100×100×13,5 *885* | 320×100×100×16 *947* | *1010* | 381×100×100×13 *1074* | 381×100×100×14,5 *1138* | 381×100×100×16,5 *1204* | *1272* |
| **14,7** | 945 | 9,15 | *3,9* | 300×100×100×15,5 *842* | 320×100×100×14,5 *904* | *966* | *1029* | 381×100×100×13,5 *1094* | 381×100×100×15 *1157* | 381×100×100×17 *1224* | *1292* |
| **15,0** | 955 | 9,15 | *3,9* | 300×100×100×16,5 *860* | 320×100×100×15 *923* | *986* | *1049* | 381×100×100×14 *1114* | 381×100×100×15,5 *1176* | 381×100×100×17,5 *1244* | 400×110×110×14 *1312* |

BULB ANGLES / CHANNELS

*For notes see page 101*

| DEPTH D | FRAME SPACING AMIDSHIPS | BASIC DRAUGHT $d_b$ | *Correction to Modulus of Main Framing per 0,3 metre difference between d and $d_b$* | DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — METRES | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **8,1** | **8,4** | **8,7** | **9,0** | **9,3** | **9,6** | **9,9** | **10,2** |
| Metres | Mm. | Metres | Per cent | Millimetres — *Modulus—centimecres*³ | | | | | | | |
| 9,3 | 715 | 7,40 | *4,8* | 300×100×100×14 *806* | 300×100×100×16,5 *858* | 320×100×100×14,5 *909* | *962* | *1016* | 381×100×100×13 *1069* | 381×100×100×14 *1122* | 381×100×100×15,5 *1171* |
| 9,6 | 730 | 7,65 | *4,6* | 300×100×100×16 *852* | 320×100×100×14,5 *905* | *958* | *1013* | 381×100×100×13 *1070* | 381×100×100×14,5 *1127* | 381×100×100×16 *1184* | 381×100×100×17 *1237* |
| 9,9 | 745 | 7,90 | *4,4* | 320×100×100×14 *895* | *952* | *1008* | 381×100×100×13 *1066* | 381×100×100×14 *1125* | 381×100×100×16 *1185* | *1243* | 400×110×110×14 *1300* |
| 10,2 | 755 | 8,15 | *4,3* | 320×100×100×16 *943* | *1002* | *1060* | 381×100×100×14 *1123* | 381×100×100×16 *1184* | 381×100×100×17,5 *1247* | 400×110×110×14 *1308* | 400×110×110×15 *1366* |
| 10,5 | 765 | 8,40 | *4,2* | *994* | *1055* | 381×100×100×14 *1116* | 381×100×100×15,5 *1180* | 381×100×100×17,5 *1245* | 400×110×110×14 *1311* | 400×110×110×15,5 *1375* | 400×110×110×17 *1437* |
| 10,8 | 780 | 8,65 | *4,1* | *1044* | 381×100×100×14 *1109* | 381×100×100×15,5 *1175* | 381×100×100×17,5 *1242* | 400×110×110×14 *1310* | 400×110×110×15,5 *1380* | 400×110×110×17 *1446* | *1511* |
| 11,1 | 795 | 8,85 | *4,0* | 381×100×100×13 *1093* | 381×100×100×15 *1160* | 381×100×100×17 *1228* | *1298* | 400×110×110×15,5 *1370* | 400×110×110×17 *1442* | *1512* | *1581* |
| 11,4 | 805 | 9,00 | *3,9* | 381×100×100×14,5 *1131* | 381×100×100×16,5 *1201* | *1271* | 400×110×110×14,5 *1344* | 400×110×110×16,5 *1418* | *1492* | | |
| 11,7 | 815 | 9,15 | *3,9* | 381×100×100×15 *1151* | 381×100×100×17 *1221* | *1291* | 400×110×110×15 *1364* | 400×110×110×17 *1439* | *1515* | | |
| 12,0 | 830 | 9,15 | *3,9* | 381×100×100×15,5 *1172* | 381×100×100×17,5 *1241* | 400×110×110×14 *1311* | 400×110×110×15,5 *1384* | 400×110×110×17,5 *1460* | *1540* | | |
| 12,3 | 845 | 9,15 | *3,9* | 381×100×100×16 *1192* | 381×100×100×18 *1262* | 400×110×110×14,5 *1332* | 400×110×110×16,5 *1405* | 400×110×110×18 *1482* | *1568* | | |
| 12,6 | 855 | 9,15 | *3,9* | 381×100×100×16,5 *1214* | *1284* | 400×110×110×15 *1354* | 400×110×110×17 *1427* | *1505* | *1587* | | |
| 12,9 | 865 | 9,15 | *3,9* | 381×100×100×17 *1235* | 400×110×110×14 *1304* | 400×110×110×15,5 *1375* | 400×110×110×17,5 *1449* | *1526* | *1610* | | |
| 13,2 | 880 | 9,15 | *3,9* | 381×100×100×17,5 *1255* | 400×110×110×14,5 *1326* | 400×110×110×16 *1397* | 400×110×110×18 *1470* | *1550* | *1633* | | |
| 13,5 | 895 | 9,15 | *3,9* | *1275* | 400×110×110×14,5 *1346* | 400×110×110×16,5 *1418* | *1492* | *1570* | | | |
| 13,8 | 905 | 9,15 | *3,9* | *1296* | 400×110×110×15 *1367* | 400×110×110×17 *1439* | *1514* | *1590* | | | |
| 14,1 | 915 | 9,15 | *3,9* | 400×110×110×14 *1317* | 400×110×110×15,5 *1387* | 400×110×110×17,5 *1459* | *1533* | *1610* | | | |
| 14,4 | 930 | 9,15 | *3,9* | 400×110×110×14,5 *1340* | 400×110×110×16,5 *1410* | 400×110×110×18 *1481* | *1557* | | | | |
| 14,7 | 945 | 9,15 | *3,9* | 400×110×110×15 *1361* | 400×110×110×17 *1431* | *1502* | | | | | |
| 15,0 | 955 | 9,15 | *3,9* | 400×110×110×15,5 *1381* | 400×110×110×17,5 *1451* | *1523* | | | | | |

CHANNELS

## NOTES.—TABLE 12

1. **Correction to modulus of peak framing.**

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than $d_b$, modulus to be $\frac{\text{increased}}{\text{reduced}}$ by 9 per cent per 0,3 metre of difference.

2. **Corrections to modulus of main framing.**—The Table modulus is to be corrected, if necessary, as follows:—

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than $d_b$, modulus to be $\frac{\text{increased}}{\text{reduced}}$ by the percentage given in the Table per 0,3 metre of difference.

FOR TANK SIDE BRACKETS AND BEAM KNEES.

If the height of the tank side brackets above the inner bottom is greater than that derived from Tables 6 and 11 or the depth of the beam knees greater than that required by Table 28 the modulus may be reduced at the rate of 4 per cent per 0,3 metre of difference.

If the height of the tank side brackets above the inner bottom is less than that derived from Tables 6 and 11 the modulus is to be increased at the rate of 8 per cent per 0,3 metre of difference.

FOR FRAME SPACING.

If the spacing amidships differs from that given in the Table, modulus to be modified in direct proportion. (*See* also D 604 to D 607.)

3. For framing in deep water ballast tanks, in oil fuel bunkers and in machinery spaces *see* D 19, D 20 and D 22.

4. For increase in boiler rooms and coal bunkers *see* D 614.

5. Particulars of sections and moduli are given in Table 56.

# TABLE 13

## 'TWEEN DECK FRAMING

| DEPTH D | FRAME SPACING AMIDSHIPS | BASIC DRAUGHT $d_b$ | *CORRECTION TO MODULUS PER 0.3 METRE DIFFERENCE BETWEEN d and $d_b$* | A | B | C | D | E | F | |
|---|---|---|---|---|---|---|---|---|---|---|
| Metres | Mm. | Metres | Per cent | MILLIMETRES *Modulus—Cms.³* | | | | | | |
| **3,6** | 545 | 2,85 | *13,8* | | 75×65× 7<br>*15,0* | 75×65×10<br>*21,0* | | | 75×65× 7<br>*15,0* | ANGLES |
| **4,2** | 555 | 3,35 | *13,4* | | 75×75× 8,5<br>*18,0* | 90×75× 9<br>*26,0* | | | 75×75× 7,5<br>*16,5* | |
| **4,8** | 570 | 3,85 | *12,9* | | 90×75× 7,5<br>*22,0* | 100×75× 9<br>*32,0* | | | 75×75× 8,5<br>*18,5* | |
| **5,4** | 580 | 4,35 | *12,4* | | 90×75× 9<br>*26,5* | 100×75×11<br>*39,0* | 130×75× 9<br>*52,5* | | 75×75×10<br>*21,0* | |
| **6,0** | 595 | 4,75 | *11,9* | | 90×75×11<br>*31,5* | 130×75× 8,5<br>*47,5* | 130×75×11<br>*63,5* | | 90×75× 8<br>*24,0* | |
| **6,6** | 605 | 5,25 | *11,3* | | 100×75×10,5<br>*37,0* | 130×75×10<br>*58,0* | 150×75×10<br>*75,0* | | 100×75× 8<br>*28,0* | |
| **7,2** | 630 | 5,75 | *10,7* | 100×75×10<br>*35,5* | 130×75× 8<br>*44,0* | 150×75× 9,5<br>*71,5* | *88,0* | | 100×75× 9<br>*32,5* | |
| **7,8** | 655 | 6,25 | *10,1* | 100×75×12,5<br>*43,0* | 130×75× 9<br>*51,5* | 150×75×12<br>*87,0* | 150×75× 8<br>*103* | *140* | 100×75×11<br>*38,0* | |
| **8,4** | 680 | 6,75 | *9,6* | 130×75× 9<br>*52,0* | 130×75×10,5<br>*60,0* | 150×75× 8<br>*104* | 150×75×10<br>*121* | 180×90× 8,5<br>*164* | 130×75× 8<br>*45,0* | |
| **9,0** | 705 | 7,15 | *9,0* | 130×75×11<br>*62,0* | 150×75× 9,5<br>*71,0* | 150×75×10,5<br>*125* | 165×75× 9,5<br>*142* | 180×90×11<br>*191* | 130×75× 9<br>*53,0* | |
| **9,6** | 730 | 7,65 | *8,3* | 150×75×10<br>*73,5* | 150×75×11,5<br>*83,5* | 165×75×10<br>*148* | 180×90× 9<br>*169* | *219* | 130×75×11<br>*62,5* | |
| **10,2** | 755 | 8,15 | *7,5* | 150×75×12<br>*86,5* | 150×75× 7,5<br>*99,5* | 180×90× 9,5<br>*173* | *203* | 200×90×12<br>*252* | 150×75×10<br>*73,5* | |
| **10,8** | 780 | 8,65 | *6,7* | 150×75× 7,5<br>*102* | 150×75×10<br>*119* | *203* | 200×90×11<br>*242* | *289* | 150×75×11,5<br>*85,0* | BULB ANGLES |
| **11,4** | 805 | 9,00 | *6,1* | 150×75×10<br>*122* | 165×75× 9,5<br>*142* | 200×90×11<br>*242* | *283* | *329* | 150×75×13<br>*97,0* | |
| **12,0** | 830 | 9,15 | *5,9* | 165×75× 8<br>*129* | 165×75×10,5<br>*151* | 200×90×12<br>*257* | *300* | 230×90×12,5<br>*353* | 150×75× 8<br>*106* | |
| **12,6** | 855 | 9,15 | *5,9* | 165×75× 9<br>*136* | 180×90× 8,5<br>*159* | 200×90×13<br>*271* | *317* | *378* | 150×75× 9<br>*114* | |
| **13,2** | 880 | 9,15 | *5,9* | 165×75× 9,5<br>*143* | 180×90× 9<br>*168* | *286* | 230×90×11,5<br>*334* | 250×90×11<br>*403* | 150×75×10<br>*122* | |
| **13,8** | 905 | 9,15 | *5,9* | 165×75×10,5<br>*151* | 180×90× 9,5<br>*176* | *301* | 230×90×12,5<br>*350* | 250×90×12,5<br>*428* | 165×75× 8<br>*130* | |
| **14,4** | 930 | 9,15 | *5,9* | 180×90× 8<br>*158* | 180×90×10,5<br>*185* | *315* | *367* | 250×90×13,5<br>*453* | 165×75× 9<br>*138* | |
| **15,0** | 955 | 9,15 | *5,9* | 180×90× 9<br>*65* | 180×90×11,5<br>*194* | 230×90×11,5<br>*330* | *384* | *478* | 165×75×10<br>*147* | |

*For notes see page 103*

## NOTES.—TABLE 13

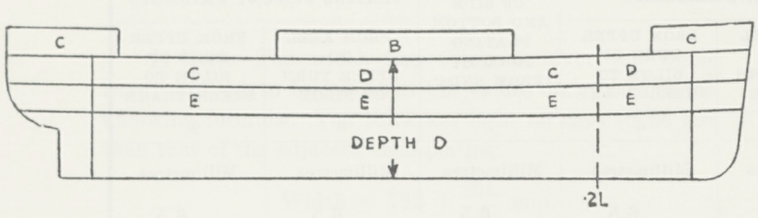



Diagram I

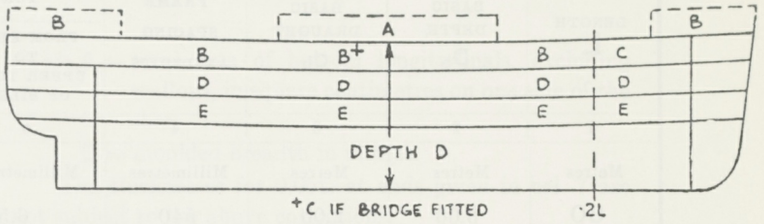



Diagram II

1. **Scantlings.**—The scantlings of the 'tween deck frames are given in cols. A to F. The positions to which each column between A and E applies are shown in the diagrams; for col. F *see* note 3. The scantlings given in the Table apply to frames fitted at every frame.

Diagram I is to be used when the ratio of draught d to depth D exceeds 0,75.

Diagram II is to be used when the ratio of draught d to depth D is—

less than 0,68 when D exceeds 6,7 metres
„ „ 0,60 „ D is 5,5 metres;
intermediate values to be obtained by interpolation.

When the value of the ratio d/D falls between the limits defined above the scantlings of the framing are to be determined by interpolation.

2. **Corrections to modulus of framing.**

FOR DRAUGHT.

If d is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than $d_b$ modulus to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ by the percentage given in the Table per 0,3 metre of difference.

FOR FRAME SPACING.

If the spacing amidships differs from that given in the Table, modulus to be modified in direct proportion. (*See* also D 604 to D 607.)

FOR 'TWEEN DECK HEIGHT.

If the 'tween deck height at side is greater than 2,6 metres, modulus to be increased in direct proportion.

3. If the framing in a 'tween deck consists of alternate frames extended from below with intermediate frames the mean modulus per frame space is to be as required for uniform framing, but the modulus of the intermediate frames is not to be less than that given in col. F. If frames are fitted two spaces apart (*see* D 609) the mean modulus per frame space is to be maintained.

4. Where several tiers of superstructures are fitted the scantlings and arrangements of the framing will be specially considered.

5. For increase in 'tween deck bunkers *see* D 614.

6. Particulars of sections and moduli are given in Table 56.

# TABLE 14

## SHELL PLATING

| LENGTH L | BASIC DEPTH $D_b$ | BASIC DRAUGHT $d_b$ | FRAME SPACING AMIDSHIPS | THICKNESS OF SHELL PLATING FOR 0,4 L AMIDSHIPS | | THICKNESS OF SIDE AND BOTTOM PLATING FOR 0.05 L FROM ENDS | MINIMUM THICKNESS OF SHELL PLATING FOR 0,4 L AMIDSHIPS | |
|---|---|---|---|---|---|---|---|---|
| | | | | FROM KEEL TO UPPER TURN OF BILGE | FROM UPPER TURN OF BILGE TO SHEERSTRAKE | | FROM KEEL TO UPPER TURN OF BILGE | FROM UPPER TURN OF BILGE TO SHEERSTRAKE |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Metres | Metres | Metres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres |
| 30 | 3,00 | 2,00 | 540 | 6,5 | 6,5 | 6,5 | 6,5 | 6,5 |
| 35 | 3,25 | 2,40 | 550 | 7 | 7 | 6,5 | 7 | 7 |
| 40 | 3,50 | 2,70 | 560 | 7,5 | 7,5 | 7 | 7,5 | 7 |
| 45 | 3,75 | 3,00 | 570 | 8,5 | 8 | 7,5 | 8 | 7,5 |
| 50 | 4,00 | 3,40 | 580 | 9 | 8,5 | 8 | 8,5 | 8 |
| 55 | 4,30 | 3,70 | 590 | 9,5 | 8,5 | 8 | 8,5 | 8 |
| 60 | 4,80 | 4,00 | 600 | 10 | 9 | 8 | 9 | 8,5 |
| 65 | 5,30 | 4,30 | 610 | 10 | 9,5 | 8,5 | 9,5 | 9 |
| 70 | 5,80 | 4,60 | 620 | 10,5 | 10 | 8,5 | 9,5 | 9,5 |
| 75 | 6,30 | 4,90 | 630 | 11 | 10,5 | 9 | 10 | 10 |
| 80 | 6,80 | 5,20 | 640 | 11,5 | 10,5 | 9 | 10,5 | 10 |
| 85 | 7,30 | 5,50 | 650 | 12 | 11 | 9,5 | 11 | 10,5 |
| 90 | 7,80 | 5,80 | 660 | 12 | 11,5 | 9,5 | 11 | 10,5 |
| 95 | 8,30 | 6,10 | 670 | 12,5 | 12 | 9,5 | 11,5 | 11 |
| 100 | 8,80 | 6,50 | 680 | 13 | 12,5 | 10 | 11,5 | 11 |
| 105 | 9,30 | 6,90 | 690 | 13,5 | 13 | 10 | 12 | 11,5 |
| 110 | 9,80 | 7,30 | 700 | 14,5 | 13,5 | 10 | 12,5 | 11,5 |
| 115 | 10,30 | 7,80 | 710 | 15 | 14 | 10 | 13 | 12 |
| 120 | 10,80 | 8,30 | 720 | 15,5 | 14,5 | 10,5 | 13,5 | 12,5 |
| 125 | 11,30 | 8,70 | 730 | 16 | 15 | 10,5 | 13,5 | 12,5 |
| 130 | 11,80 | 8,90 | 740 | 16,5 | 15 | 11 | 14 | 13 |
| 135 | 12,30 | 9,10 | 750 | 17 | 15,5 | 11 | 14,5 | 13,5 |
| 140 | 12,80 | 9,30 | 760 | 17,5 | 15,5 | 11,5 | 15 | 14 |
| 145 | 13,30 | 9,50 | 770 | 18 | 16 | 11,5 | 15,5 | 14,5 |
| 150 | 13,80 | 9,70 | 780 | 18,5 | 16,5 | 11,5 | 16,5 | 15 |
| 155 | 14,30 | 9,90 | 790 | 19 | 16,5 | 12 | 17 | 15,5 |
| 160 | 14,80 | 10,00 | 800 | 19,5 | 17 | 12 | 17,5 | 16 |
| 165 | 15,30 | 10,15 | 810 | 20 | 17,5 | 12 | 18 | 16,5 |
| 170 | 15,80 | 10,30 | 820 | 20,5 | 18 | 12,5 | 18,5 | 16,5 |
| 175 | 16,30 | 10,45 | 830 | 21 | 18,5 | 12,5 | 19 | 16,5 |
| 180 | 16,80 | 10,55 | 840 | 21,5 | 18,5 | 12,5 | 19,5 | 17 |
| 185 | 17,30 | 10,65 | 850 | 22 | 19 | 13 | 20 | 17 |
| 190 | 17,80 | 10,75 | 860 | 22,5 | 19,5 | 13 | 20,5 | 17 |
| 195 | 18,30 | 10,85 | 870 | 23 | 20 | 13 | 21 | 17 |
| 200 | 18,80 | 10,95 | 880 | 23,5 | 20,5 | 13 | 21 | 17 |

*For notes see page 105*

## NOTES.—TABLE 14

**1. Keel.**—The width and thickness over the whole length are not to be less than the values derived from the following formulæ. The thickness is in no case to be less than that of the adjacent shell plating.

$$\text{Width} = 762 + \frac{25L}{6} \text{ mm.}$$

$$\text{Thickness} = 5{,}84 + \frac{5L}{48} \text{ mm.}$$

**2. Garboard strake.**—If a bar keel is fitted, the thickness of the garboard strake is to be 85 per cent of that required for a keel plate (Note 1); this thickness is to be maintained for 0,4L amidships and may be 85 per cent of the midship thickness for 0,05L at the ends, but in way of strengthening of bottom forward is not to be less than required for bottom plating.

**3. Bottom and side plating.**—The Table thickness of bottom and side plating for 0,4L amidships (cols. 5 and 6) is to be corrected, if necessary, as follows:—

For depth.

If D is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than $D_b$, thickness to be $\begin{matrix}\text{reduced}\\\text{increased}\end{matrix}$ by 0,7 per cent per 0,3 metre of difference.

For draught.

If d is less than $d_b$, thickness to be reduced by 1,5 per cent per 0,3 metre of difference. If d is greater than $d_b$, no correction is required.

If both these corrections are required the factors derived from each correction are to be multiplied together and not applied separately to the Table thickness. (*Example: Correction for depth* +1,22%; *correction for draught* −3,37%; *total factor* 1,012×0,966 = 0,978).

**For Longitudinal framing**

Where the bottom is framed longitudinally the thickness of the bottom shell plating, after correction for depth and draught, if necessary, may be reduced by $\frac{0{,}18A}{B}$ mm.

where A = total area of bottom longitudinals, excluding scallops, in square centimetres on one side of the ship,

B = moulded breadth in metres.

The thicknesses for 0,05L at ends given in col. 7 are not subject to the above corrections.

**4. Effective superstructure.**—If an effective superstructure as defined in D 206 is fitted, the shell plating may be modified as stated in D 703.

**5. Frame spacing.**—If the spacing amidships differs from the Table spacing (col. 4) the thickness of bottom and side plating is to be modified at the rate of 0,5 mm. for every 50 mm. of difference, but where the spacing amidships exceeds the Table spacing by 75 mm. or more the increase required will be specially considered.

Where the bottom is framed longitudinally a spacing correction is only required (except as given in Note 6) if the spacing exceeds that given in Table 10 by 75 mm. or more when the increase required will be specially considered.

**6. Minimum thickness.**—The thickness of the bottom and side plating for 0,4L amidships, after correction as required by Notes 3 and 5, is not to be less than that given in cols. 8 and 9, corrected as required by Note 5 only.

Where the bottom is framed longitudinally the minimum thickness of bottom shell (col. 8) is to be modified at the rate of 0,5 mm. for every 50 mm. of difference between the actual spacing and that given in Table 10.

**7. Local strengthening.**—Plates connected to the sternframe or propeller brackets are to have the thickness given in col. 6 without corrections and those which require to be furnaced are to be of that thickness when finished.

For strengthening of bottom forward *see* D 802.

For strengthening at openings in shell *see* D 705 and D 706.

For strengthening at ends of superstructures *see* D 1206 and D 1305 to D 1308.

For strengthening for navigation in ice *see* D 1003, D 1011 and D 1019.

# TABLE 15

## BEAMS IN PEAKS BELOW LOWEST DECK

| BREADTH B | BEAM | | KNEE | RIVETS | |
|---|---|---|---|---|---|
| Metres | | Millimetres | Millimetres | Number | mm. |
| 7 | BULB ANGLES | 130 × 65 × 8 | 380 × 8 | 4 | 19 |
| 8 | | 140 × 65 × 8 | 385 × 8 | 4 | 19 |
| 9 | | 140 × 65 × 9 | 415 × 8,5 | 5 | 19 |
| 10 | | 150 × 75 × 9 | 445 × 8,5 | 6 | 19 |
| 11 | | 150 × 75 × 10,5 | 485 × 9 | 6 | 19 |
| 12 | | 165 × 75 × 10,5 | 525 × 9,5 | 6 | 19 |
| 13 | | 180 × 75 × 11 | 565 × 9,5 | 6 | 22 |
| 14 | | 180 × 90 × 11,5 | 610 × 9,5 | 6 | 22 |
| 15 | | 200 × 90 × 11,5 | 650 × 10 | 6 | 22 |
| 16 | | 230 × 90 × 11 | 690 × 10,5 | 7 | 22 |
| 17 | CHANNELS | 200 × 85 × 85 × 12 | 735 × 11 | 7 | 22 |

**NOTE.—TABLE 15**

Where B is greater than 17 metres the scantlings of the beams are to be specially considered in relation to the size and form of the ship.

TABLE 16

## STRINGERS IN PANTING REGION

| LENGTH L | FORWARD OF COLLISION BULKHEAD | | ABAFT COLLISION BULKHEAD | | |
|---|---|---|---|---|---|
| | STRINGER PLATE | | THICKNESS OF INTERCOSTAL PLATE | FACE ANGLE | |
| | WIDTH | THICKNESS | | | |
| Metres | Millimetres | Millimetres | Millimetres | | Millimetres |
| 30 | 555 | 6,5 | 7 | ANGLES | 65 × 65 × 7,5 |
| 60 | 630 | 7,5 | 8 | ANGLES | 75 × 75 × 9,0 |
| 90 | 705 | 8 | 9 | ANGLES | 120 × 75 × 10,0 |
| 120 | 805 | 9 | 10 | ANGLES | 150 × 90 × 10,5 |
| 150 | 905 | 9,5 | 10,5 | BULB ANGLES | 180 × 90 × 10,5 |
| 180 | 1005 | 10,5 | 11,5 | BULB ANGLES | 200 × 90 × 12,0 |

TABLE 17

## ICE STRENGTHENING—CLASS 3
## INTERMEDIATE FRAMES

| LENGTH L | INTERMEDIATE FRAMES | | | |
|---|---|---|---|---|
| | FORWARD OF COLLISION BULKHEAD | | ABAFT COLLISION BULKHEAD | |
| Metres | Millimetres *Modulus—Centimetres*³ | | | |
| 30 | ANGLES | 75 × 65 × 7,0 *15,1* | ANGLES | 100 × 75 × 9,0 *32,4* |
| 40 | ANGLES | 75 × 75 × 8,5 *18,2* | ANGLES | 100 × 75 × 11,0 *38,7* |
| 60 | ANGLES | 90 × 75 × 9,5 *27,2* | ANGLES | 120 × 75 × 11,5 *56,2* |
| 80 | ANGLES | 120 × 75 × 9,0 *43,9* | ANGLES | 150 × 75 × 11,0 *82,9* |
| 100 | ANGLES | 150 × 75 × 9,0 *68,0* | BULB ANGLES | 150 × 75 × 9,5 *118,0* |
| 120 | ANGLES | 150 × 90 × 13,5 *97,7* | BULB ANGLES | 180 × 75 × 8,5 *161,0* |
| 140 | ANGLES | 180 × 90 × 12,5 *131,0* | BULB ANGLES | 200 × 75 × 9,0 *211,0* |
| 160 | BULB ANGLES | 180 × 75 × 8,5 *163,0* | BULB ANGLES | 200 × 90 × 12,5 *262,0* |

# TABLE 18

(SEE CONTINUATION)

## TOPSIDE SCANTLINGS

| LENGTH L | BASIC BREADTH $B_b$ | BASIC DEPTH $D_b$ | BASIC DRAUGHT $d_b$ | BEAM SPACING AMIDSHIPS | WIDTH OF SHEERSTRAKE AND STRINGER PLATE OF PLATED DECK. | THICKNESS OF SHEERSTRAKE FOR 0,4L AMIDSHIPS | SECTIONAL AREAS OF STRENGTH DECK FOR 0,4L AMIDSHIPS AND CORRECTIONS FOR DEPTH, DRAUGHT AND BEAM. (Col.17) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | WHERE ONE DECK FITTED | | |
| | | | | | | | SECTIONAL AREA | *CORRECTION PER 0,3 METRE DIFFERENCE BETWEEN:* | |
| | | | | | | | | D *and* $D_b$ | d *and* $d_b$ |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Metres | Metres | Metres | Metres | Millimetres | Millimetres | Millimetres | Square Centimetres | Per cent | Per cent |
| 30 | 7,5 | 3,00 | 2,00 | 540 | 1060 | 7,5 | 70 | *18,15* | *18,20* |
| 35 | 8 | 3,25 | 2,40 | 550 | 1070 | 8 | 85 | *14,90* | *16,60* |
| 40 | 8,5 | 3,50 | 2,70 | 560 | 1120 | 8,5 | 100 | *12,95* | *15,40* |
| 45 | 9 | 3,75 | 3,00 | 570 | 1150 | 9,5 | 130 | *11,45* | *14,40* |
| 50 | 9,5 | 4,00 | 3,40 | 580 | 1165 | 10 | 165 | *10,35* | *13,10* |
| 55 | 10 | 4,3 | 3,70 | 590 | 1195 | 10,5 | 200 | *9,50* | *12,15* |
| 60 | 10,5 | 4,8 | 4,00 | 600 | 1235 | 11,5 | 235 | *8,80* | *11,10* |
| 65 | 11 | 5,3 | 4,30 | 610 | 1270 | 12 | 270 | *8,10* | *10,25* |
| 70 | 11,5 | 5,8 | 4,60 | 620 | 1300 | 12,5 | 305 | *7,55* | *9,45* |
| 75 | 12 | 6,3 | 4,90 | 630 | 1320 | 13 | 345 | *7,15* | *8,65* |
| 80 | 12,5 | 6,8 | 5,20 | 640 | 1345 | 13,5 | 390 | *6,75* | *7,90* |
| 85 | 13 | 7,3 | 5,50 | 650 | 1365 | 14 | 450 | *6,40* | *7,20* |
| 90 | 13,5 | 7,8 | 5,80 | 660 | 1385 | 14,5 | 520 | *6,15* | *6,70* |
| 95 | 14 | 8,3 | 6,10 | 670 | 1405 | 15 | 595 | *5,90* | *6,15* |
| 100 | 14,5 | 8,8 | 6,50 | 680 | 1425 | 15,5 | 675 | *5,65* | *5,55* |
| 105 | 15 | 9,3 | 6,90 | 690 | 1445 | 16 | 760 | *5,40* | *5,00* |
| 110 | 15,5 | 9,8 | 7,30 | 700 | 1470 | 17 | 885 | *5,15* | *4,55* |
| 115 | 16 | 10,3 | 7,80 | 710 | 1490 | 18,5 | 1010 | *4,90* | *4,15* |
| 120 | 16,5 | 10,8 | 8,30 | 720 | 1510 | 19,5 | 1140 | *4,70* | *3,75* |
| 125 | 17 | 11,3 | 8,70 | 730 | 1530 | 20,5 | 1280 | *4,45* | *3,60* |
| 130 | 17,5 | 11,8 | 8,90 | 740 | 1550 | 21 | 1380 | *4,25* | *3,60* |
| 135 | 18 | 12,3 | 9,10 | 750 | 1570 | 21,5 | 1495 | *4,10* | *3,55* |
| 140 | 18,5 | 12,8 | 9,30 | 760 | 1595 | 21,5 | 1605 | *3,95* | *3,55* |
| 145 | 19 | 13,3 | 9,50 | 770 | 1615 | 22 | | | |
| 150 | 19,5 | 13,8 | 9,70 | 780 | 1635 | 22,5 | | | |
| 155 | 20 | 14,3 | 9,90 | 790 | 1655 | 23 | | | |
| 160 | 20,5 | 14,8 | 10,00 | 800 | 1675 | 23,5 | | | |
| 165 | 21 | 15,3 | 10,15 | 810 | 1700 | 24,5 | | | |
| 170 | 21,5 | 15,8 | 10,30 | 820 | 1720 | 25 | | | |
| 175 | 22 | 16,3 | 10,45 | 830 | 1740 | 26 | | | |
| 180 | 22,5 | 16,8 | 10,55 | 840 | 1755 | 27 | | | |
| 185 | 23 | 17,3 | 10,65 | 850 | 1795 | 28 | | | |
| 190 | 23,5 | 17,8 | 10,75 | 860 | 1835 | 28,5 | | | |
| 195 | 24 | 18,3 | 10,85 | 870 | 1880 | 29,5 | | | |
| 200 | 24,5 | 18,8 | 10,95 | 880 | 1920 | 30 | | | |

*For notes see pages 110 & 111*

# TABLE 18

(SEE CONTINUATION)

| SECTIONAL AREA OF STRENGTH DECK FOR 0,4 L AMIDSHIPS AND CORRECTIONS FOR DEPTH, DRAUGHT AND BEAM | | | | | | | MINIMUM THICKNESS OF UNSHEATHED PLATING OF STRENGTH DECK FOR 0,4 L AMIDSHIPS | | THICKNESS OF UNSHEATHED PLATING OF STRENGTH DECK FOR 0,1 L FROM ENDS | | LENGTH L |
|---|---|---|---|---|---|---|---|---|---|---|---|
| WHERE TWO DECKS FITTED | | | WHERE THREE DECKS FITTED | | | ALL STRENGTH DECKS | | | | | |
| SECTIONAL AREA | *CORRECTION PER 0,3 METRE DIFFERENCE BETWEEN:* D *and* $D_b$ | *CORRECTION PER 0,3 METRE DIFFERENCE BETWEEN:* d *and* $d_b$ | SECTIONAL AREA | *CORRECTION PER 0,3 METRE DIFFERENCE BETWEEN:* D *and* $D_b$ | *CORRECTION PER 0,3 METRE DIFFERENCE BETWEEN:* d *and* $d_b$ | *CORRECTION PER 0,3 METRE DIFFERENCE BETWEEN* B *and* $B_b$ | OUTSIDE LINE OF OPENINGS | INSIDE LINE OF OPENINGS | STRINGER | PLATING | |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| Square Centimetres | Per cent | Per cent | Square Centimetres | Per cent | Per cent | Per cent | Millimetres | Millimetres | Millimetres | Millimetres | Metres |
| | | | | | | *3,95* | 6,5 | 6,5 | 6,5 | 6,5 | 30 |
| | | | | | | *3,95* | 6,5 | 6,5 | 6,5 | 6,5 | 35 |
| | | | | | | *3,95* | 7 | 7 | 7 | 6,5 | 40 |
| | | | | | | *3,95* | 7 | 7 | 7 | 6,5 | 45 |
| | | | | | | *3,95* | 7,5 | 7 | 7,5 | 7 | 50 |
| 180 | *13,40* | *9,85* | | | | *3,95* | 8 | 7 | 7,5 | 7 | 55 |
| 210 | *12,45* | *9,55* | | | | *3,95* | 8 | 7,5 | 8 | 7 | 60 |
| 240 | *11,65* | *9,35* | | | | *3,95* | 8 | 7,5 | 8 | 7 | 65 |
| 270 | *10,85* | *9,10* | | | | *3,95* | 8,5 | 7,5 | 8 | 7 | 70 |
| 305 | *10,10* | *8,85* | | | | *3,95* | 8,5 | 7,5 | 8,5 | 7,5 | 75 |
| 350 | *9,35* | *8,50* | | | | *3,95* | 9 | 8 | 8,5 | 7,5 | 80 |
| 395 | *8,85* | *8,20* | | | | *3,95* | 9 | 8 | 9 | 7,5 | 85 |
| 440 | *8,45* | *7,85* | | | | *3,95* | 9,5 | 8 | 9 | 7,5 | 90 |
| 495 | *8,05* | *7,25* | | | | *3,80* | 9,5 | 8,5 | 9 | 7,5 | 95 |
| 560 | *7,70* | *6,50* | 540 | *9,80* | *6,85* | *3,65* | 9,5 | 8,5 | 9,5 | 8 | 100 |
| 625 | *7,45* | *5,95* | 595 | *9,15* | *6,25* | *3,50* | 10 | 8,5 | 9,5 | 8 | 105 |
| 715 | *7,15* | *5,35* | 690 | *8,50* | *5,55* | *3,35* | 10 | 9 | 10 | 8 | 110 |
| 825 | *6,80* | *4,80* | 795 | *8,00* | *5,00* | *3,20* | 10,5 | 9 | 10 | 8 | 115 |
| 940 | *6,55* | *4,30* | 895 | *7,60* | *4,50* | *3,00* | 10,5 | 9 | 10 | 8 | 120 |
| 1030 | *6,30* | *4,05* | 1000 | *7,25* | *4,25* | *2,85* | 11 | 9 | 10 | 8,5 | 125 |
| 1115 | *5,95* | *3,95* | 1075 | *7,00* | *4,15* | *2,70* | 11 | 9 | 10 | 8,5 | 130 |
| 1205 | *5,70* | *3,85* | 1160 | *6,80* | *4,05* | *2,55* | 11,5 | 9,5 | 10,5 | 8,5 | 135 |
| 1295 | *5,40* | *3,75* | 1235 | *6,60* | *3,95* | *2,35* | 11,5 | 9,5 | 10,5 | 8,5 | 140 |
| 1385 | *5,10* | *3,70* | 1305 | *6,45* | *3,90* | *2,20* | 12 | 9,5 | 10,5 | 8,5 | 145 |
| 1485 | *4,80* | *3,70* | 1375 | *6,30* | *3,85* | *2,05* | 12 | 9,5 | 10,5 | 8,5 | 150 |
| 1580 | *4,50* | *3,65* | 1460 | *5,95* | *3,85* | *2,00* | 12 | 9,5 | 10,5 | 9 | 155 |
| 1730 | *4,10* | *3,60* | 1580 | *5,25* | *3,75* | *2,00* | 12,5 | 10 | 11 | 9 | 160 |
| 1870 | *3,70* | *3,55* | 1710 | *4,80* | *3,70* | *2,00* | 12,5 | 10 | 11 | 9 | 165 |
| 2005 | *3,40* | *3,45* | 1840 | *4,35* | *3,60* | *2,00* | 12,5 | 10 | 11 | 9 | 170 |
| 2140 | *3,20* | *3,45* | 1965 | *3,90* | *3,55* | *2,00* | 12,5 | 10 | 11 | 9 | 175 |
| | | | 2110 | *3,55* | *3,50* | *2,00* | 12,5 | 10 | 11 | 9 | 180 |
| | | | 2240 | *3,35* | *3,45* | *2,00* | 12,5 | 10,5 | 11,5 | 9 | 185 |
| | | | 2365 | *3,15* | *3,45* | *2,00* | 12,5 | 10,5 | 11,5 | 9,5 | 190 |
| | | | 2510 | *3,05* | *3,40* | *2,00* | 12,5 | 10,5 | 11,5 | 9,5 | 195 |
| | | | 2645 | *2,90* | *3,40* | *2,00* | 12,5 | 10,5 | 11,5 | 9,5 | 200 |

*For notes see pages 110 & 111*

## NOTES.—TABLE 18

1. **Sheerstrake.**—(*a*) The Table thickness of the sheerstrake (col. 7) is to be corrected, if necessary, as follows:—

FOR DEPTH.

If D is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than $D_b$, thickness to be $\begin{matrix}\text{reduced}\\\text{increased}\end{matrix}$ by 4 per cent per 0,3 metre of difference.

FOR DRAUGHT.

If d is less than $d_b$, thickness to be reduced by 4 per cent per 0,3 metre of difference. If d is greater than $d_b$, no correction is required.

If both corrections are required the factors derived from each correction are to be multiplied together and not applied separately to the Table thickness. (*Example: Correction for depth* +7,32%; *correction for draught* −10,16%; *total factor* =1,073×0,898=0,964.)

(*b*) The thickness of sheerstrake is not to be corrected for frame spacing, but is not to be less, for 0,4L amidships, than the side plating.

The thickness of sheerstrake at ends is to be the same as that of the side plating except in ships in which the draught does not exceed 0,7D (D being measured to the uppermost continuous deck) when the end thickness may be as required for a poop or forecastle aft or forward respectively.

2. **Plated strength deck.**—(*a*) The area given in cols. 8, 11 and 14 is the combined sectional area of deck plating, stringer plate and, where fitted, stringer angle, deck longitudinals (with area of scallops deducted) and riveted seams for one side of the ship abreast openings.

(*b*) The Table area (cols. 8, 11 and 14) is to be corrected, if necessary, as follows:—

FOR DEPTH.

If D is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than $D_b$, area to be $\begin{matrix}\text{reduced}\\\text{increased}\end{matrix}$ by the given percentage (cols. 9, 12 and 15) per 0,3 metre of difference.

FOR DRAUGHT.

If d is less than $d_b$, area to be reduced by the given percentage (cols. 10, 13 and 16) per 0,3 metre of difference. If d is greater than $d_b$, no correction is required.

FOR BREADTH.

If B is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than $B_b$, area to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ by the given percentage (col. 17) per 0,3 metre of difference.

If more than one of the above corrections is required the factors derived from the individual corrections are to be multiplied together and not applied separately to the Table area. (*Example: Correction for depth* — 13,81%; *correction for draught* — 3,92%; *correction for breadth* + 9,12%; *total factor* = 0,862 × 0,961 × 1,091 = 0,904.)

The deck area obtained after the above corrections is the minimum area. This area may require to be increased for special characteristics in design as required in note 2(*c*).

(*c*) Where there is no effective superstructure (*see* D 206) on the strength deck, the sectional area of the strength deck plating as computed from notes 2(*a*) and 2(*b*) is to be increased by multiplying the area by the factor

$$F = \frac{L \times C_b}{100 \times d} \times f_1 \times f,$$ if this factor is greater than unity.

Where $C_b$ = moulded block coefficient at load draught,

L = length between perpendiculars, in metres,

d = summer draught, in metres, measured from top of keel.

$f_1$ is a factor to be applied only when d is greater than $d_b$ and

$$f_1 = 1 + \left(\frac{d - d_b}{30}\right) C_d$$

where $C_d$ is the draught correction from cols. 10, 13 or 16 as appropriate.

f is to be determined in the following manner:—

Where *l* = length, in metres, of machinery space between main bulkheads including mean length of adjacent cross bunkers, if any.

x = distance, in metres, of centre of the length "*l*" from amidships.

m = weight of machinery, in metric tons, excluding propellers and shafting, but including all auxiliary machinery in machinery space.

W = load displacement, in metric tons.

V = sea speed, in knots.

s = product of length, mean breadth and height, in metres, of cargo space in forecastle, poop or after 'tween decks as defined below.

z = distance, in metres, of centre of length of above cargo space from amidships.

Then f is the algebraic summation of the following terms "a" and "b" in all cases and "c" and "$d_t$" where applicable.

"a", "b", "c" and "$d_t$" are obtained as follows:—

"a" is taken from Table 18A for the appropriate values of *l*/L and x/L.

"b" is calculated from Table 18B to give effect to any departure from a standard value of m/W = 0,06, and may be positive or negative.

"c". If a forecastle and/or poop is fitted on the continuous strength deck for the carriage of cargo, or if cargo is carried in the upper 'tween decks

**NOTES.—TABLE 18** *(concluded)*

abaft 0,05L forward of the after perpendicular, a further term "c" is to be calculated and added as follows:—

For a forecastle, poop and/or after 'tween deck

$$\frac{136{,}3\ s(z - 0{,}25\ l - 0{,}2L)}{WL}$$

NOTE.—In calculating "s" for an after 'tween deck the length of the space need only be measured abaft 0,05L forward of the after perpendicular.

"$d_t$". If owners desire provision to be made in the longitudinal scantlings for loaded voyages with one or more midship deep tanks empty an additional term "$d_t$" calculated for each deep tank as follows is to be added to "a", "b" and "c" when calculating the value of "f".

$$d_t = \frac{150\ C\ (0{,}25\ l + 0{,}2L - y)}{WL}$$

Where C = capacity of deep tank, in metric tons, of salt water.

y = distance, in metres, of centre of length of deep tank from amidships.

This correction is applicable to ships having machinery amidships and for midship deep tanks only; it is not to be applied to tanks at ends where the value of "$d_t$" is negative.

Special consideration will be given to the scantlings when the speed-length ratio exceeds that obtained from the following table:—

| $C_b$ | $\frac{V}{\sqrt{L \times 3{,}28}}$ |
|---|---|
| 0,60 | 0,85 |
| 0,70 | 0,75 |
| 0,80 | 0,65 |

Special consideration will also be given when the block coefficient is less than 0,60.

(*d*) Where a long continuous deckhouse extending over at least 0,15L amidships and not less in breadth than 0,8B is fitted, the increased deck area required by note 2(*c*) may extend from a distance of 0,04L inside the deckhouse at each end to 0,2L from midships. Within the remainder of the deckhouse the deck area is to be that required by note 2(*b*). (For deckhouses *see* D 1208 to D 1211.)

(*e*) The requirements of notes 2(*c*) and 2(*d*) may be modified as necessary to take account of any special features in the design arrangements not covered by the formula.

3. **'Tween deck height.**—If the midship height of the 'tween decks below the strength deck exceeds 2,6 metres at side, the area of the strength deck, corrected as required by notes 2 (*b*), 2 (*c*) and 2 (*d*) is to be increased at the rate of 5 per cent of the Rule area of the second deck in two deck ships, and 7 per cent of the Rule area of the second deck in three deck ships, per 0,3 metre increase in 'tween deck height. If the second 'tween deck height exceeds 2,6 metres, a further increase may be required.

If the midship height of the 'tween decks below the strength deck is less than 2,6 metres at side, the area of the strength deck corrected as required by notes 2 (*b*), 2 (*c*) and 2 (*d*) may be reduced at the rate of 5 per cent of the Rule area of the second deck per 0,3 metre reduction in 'tween deck height.

4. **Beam spacing.**—If the spacing of beams amidships differs from that given in col. 5, or with longitudinal framing from that given in Table 26, the minimum thickness of deck plating outside line of openings (col. 18) is to be modified at the rate of 0,5 mm. for every 100 mm. of difference, and the minimum thickness of deck plating inside line of openings (col. 19) at the rate of 0,5 mm. for each complete 200 mm.

5. **Stringer plates.**—The thickness of strength deck stringer plates amidships is not to be less than 85 per cent of the thickness of sheerstrake, corrected as required by note 1, nor less than 1 mm. greater than that given in col. 18.

The width of stringer plates for 0,1L at ends is not to be less than 60 per cent of the width amidships (col. 6).

6. **Stringer angles.**—Scantlings are to be in accordance with Table 19.

7. **Sheathed decks.**—Where plated decks are sheathed with wood or approved composition the thickness given in col. 18 may be reduced by 15 per cent in ships over 50 metres in length and by 10 per cent in smaller ships, and that given in cols. 19, 20 and 21 may be reduced by 10 per cent for all ships.

8. **Effective superstructures.**—If an effective superstructure as defined in D 206 is fitted amidships the scantlings of the upper and second decks in way of the superstructure are to be those required for the second and third decks respectively.

9. **Strength deck with stringer and tie plates.**—Stringer and tie plates fitted under a wood deck are to have the combined sectional area, for 0,4L amidships, required for a plated deck.

The width of stringer plates for 0,4L amidships is not to be less than 560 mm. and 1370 mm. for lengths of 30 metres and 80 metres respectively with intermediate values in proportion. The width for 0,1L from the ends is not to be less than 60 per cent of the width amidships.

The width of tie plates throughout is not to be less than 300 mm. and 500 mm. for lengths of 30 metres and 80 metres respectively with intermediate values in proportion.

The thickness of the stringer and tie plates is not to be less than given in col. 20, but stringer plates for 0,4L amidships are not to be less than 85 per cent of the Rule thickness of sheerstrake.

10. **Local strengthening.**—For strengthening at the ends of superstructures *see* D 1206 and D 1305 to D 1308.

For strengthening at openings *see* D 1109.

For strengthening in ships having concentrated loading amidships *see* D 1107.

## TABLE 18A

Term "a" of Basic Deck Factor f (Note 2 (c)) for $m/W = 0{,}06$

| $l/L$ | $x/L$ | | | | | |
|---|---|---|---|---|---|---|
| | 0,02 | 0,04 | 0,06 | 0,08 | 0,10 | 0,12 |
| 0,11 | 5,85 | 5,65 | 5,34 | 4,84 | 4,11 | 3,06 |
| 0,12 | 6,42 | 6,22 | 5,91 | 5,40 | 4,69 | 3,78 |
| 0,13 | 6,96 | 6,75 | 6,42 | 5,94 | 5,34 | 4,50 |
| 0,14 | 7,46 | 7,26 | 6,96 | 6,49 | 5,91 | 5,18 |
| 0,15 | 7,92 | 7,74 | 7,45 | 6,99 | 6,48 | 5,83 |
| 0,16 | 8,38 | 8,16 | 7,90 | 7,48 | 7,00 | 6,48 |
| 0,17 | 8,80 | 8,59 | 8,32 | 7,95 | 7,54 | 7,06 |
| 0,18 | 9,18 | 8,98 | 8,71 | 8,40 | 8,04 | 7,63 |
| 0,19 | 9,54 | 9,35 | 9,08 | 8,79 | 8,47 | 8,12 |
| 0,20 | 9,85 | 9,66 | 9,45 | 9,17 | 8,88 | 8,56 |
| 0,21 | 10,14 | 9,95 | 9,74 | 9,48 | 9,20 | 8,93 |

## TABLE 18B

Term "b" of Basic Deck Factor f (Note 2(c))

Value per 0,01 Difference in $m/W$ from 0,06

| $x/L$ | CORRECTION | $x/L$ | CORRECTION |
|---|---|---|---|
| 0,0 | 0,526 | 0,06 | 0,440 |
| 0,01 | 0,522 | 0,07 | 0,412 |
| 0,02 | 0,514 | 0,08 | 0,380 |
| 0,03 | 0,502 | 0,09 | 0,345 |
| 0,04 | 0,486 | 0,10 | 0,312 |
| 0,05 | 0,464 | 0,11 | 0,277 |
| | | 0,12 | 0,242 |

The term "b" is $\frac{\text{positive}}{\text{negative}}$ when $m/W$ is $\frac{\text{less}}{\text{greater}}$ than 0,06.

## STRINGER ANGLES ON STRENGTH DECKS

| THICKNESS OF SHEERSTRAKE OR STRINGER PLATE WHICHEVER IS THE GREATER | | DIAMETER OF RIVET AS REQUIRED BY TABLE 52 | SIZES OF FLANGES* | SPACING OF RIVETS |
|---|---|---|---|---|
| Above | Not exceeding | Millimetres | Millimetres | Diameters |
| Millimetres | | | | |
| — | 9 | 16 | 75 × 75 | $4\frac{1}{2}$ |
| 9 | 12,5 | 19 | 90 × 90 | $4\frac{1}{2}$ |
| 12,5 | 14 | 22 | 90 × 90 | $4\frac{1}{2}$ |
| 14 | 16 | 22 | 90 × 90 | $4\frac{1}{2}$ |
| 16 | 18,5 | 22 | 130 × 130 | 2 rows, 6 in each row |
| 18,5 | 24 | 25 | 150 × 150 | 2 „ $5\frac{1}{2}$ „ |
| 24 | 29 | 28 | 180 × 180 | 2 „ $5\frac{1}{2}$ „ |
| 29 | 30,5 | 32 | 200 × 200 | 2 „ 5 „ |

* The thickness of the stringer angle is to be that of the sheerstrake or stringer plate, whichever is the less.

# TABLE 20

## LOWER DECKS

| LENGTH L | BASIC BREADTH $B_b$ | BEAM SPACING AMIDSHIPS | SECOND DECK PLATING OUTSIDE LINE OF OPENINGS FOR 0,4 L AMIDSHIPS | | THIRD DECK PLATING OUTSIDE LINE OF OPENINGS FOR 0,4 L AMIDSHIPS | | PLATING OF SECOND & THIRD DECKS INSIDE LINE OF OPENINGS & FOR 0,1 L FROM ENDS AND OF PLATFORM DECKS THROUGHOUT (UNSHEATHED) |
|---|---|---|---|---|---|---|---|
| | | | SECTIONAL AREA | MINIMUM THICKNESS (UNSHEATHED) | SECTIONAL AREA | MINIMUM THICKNESS (UNSHEATHED) | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Metres | Metres | Millimetres | Square Cms. | Millimetres | Square Cms. | Millimetres | Millimetres |
| **50** | 9,5 | 580 | 95 | 7 | | | 6,5 |
| **55** | 10 | 590 | 105 | 7 | | | 6,5 |
| **60** | 10,5 | 600 | 115 | 7,5 | | | 6,5 |
| **65** | 11 | 610 | 125 | 7,5 | | | 6,5 |
| **70** | 11,5 | 620 | 145 | 7,5 | | | 6,5 |
| **75** | 12 | 630 | 175 | 7,5 | | | 6,5 |
| **80** | 12,5 | 640 | 205 | 7,5 | | | 6,5 |
| **85** | 13 | 650 | 240 | 8 | | | 6,5 |
| **90** | 13,5 | 660 | 280 | 8 | | | 6,5 |
| **95** | 14 | 670 | 325 | 8 | | | 6,5 |
| **100** | 14,5 | 680 | 355 | 8 | 325 | 7,5 | 7 |
| **105** | 15 | 690 | 385 | 8 | 345 | 7,5 | 7 |
| **110** | 15,5 | 700 | 415 | 8,5 | 365 | 7,5 | 7 |
| **115** | 16 | 710 | 435 | 8,5 | 390 | 7,5 | 7 |
| **120** | 16,5 | 720 | 455 | 8,5 | 410 | 7,5 | 7 |
| **125** | 17 | 730 | 480 | 8,5 | 430 | 8 | 7,5 |
| **130** | 17,5 | 740 | 505 | 8,5 | 450 | 8 | 7,5 |
| **135** | 18 | 750 | 530 | 9 | 475 | 8 | 7,5 |
| **140** | 18,5 | 760 | 565 | 9 | 495 | 8 | 7,5 |
| **145** | 19 | 770 | 595 | 9 | 520 | 8 | 7,5 |
| **150** | 19,5 | 780 | 625 | 9 | 545 | 8,5 | 7,5 |
| **155** | 20 | 790 | 665 | 9,5 | 575 | 8,5 | 8 |
| **160** | 20,5 | 800 | 695 | 9,5 | 605 | 8,5 | 8 |
| **165** | 21 | 810 | 730 | 10 | 640 | 9 | 8 |
| **170** | 21,5 | 820 | 765 | 10 | 670 | 9 | 8 |
| **175** | 22 | 830 | 800 | 10,5 | 695 | 9 | 8 |
| **180** | 22,5 | 840 | 830 | 10,5 | 720 | 9,5 | 8 |
| **185** | 23 | 850 | 860 | 10,5 | 755 | 9,5 | 8 |
| **190** | 23,5 | 860 | 900 | 11 | 785 | 10 | 8,5 |
| **195** | 24 | 870 | 930 | 11 | 830 | 10 | 8,5 |
| **200** | 24,5 | 880 | 965 | 11 | 865 | 10 | 8,5 |

# LOWER DECKS

## NOTES.—TABLE 20

1. **Sectional area.**—The Table area of lower decks (cols. 4 and 6) is for one side of the ship outside the line of hatchways or other openings and inside the line of notches for 'tween deck frames; it includes overlapped seams, if fitted.

2. **Corrections.**

FOR BREADTH.

If B differs from $B_b$ (col. 2) the area is to be modified in direct proportion.

FOR BEAM SPACING.

If the spacing of beams fitted at every frame, or of longitudinals, differs from that in col. 3 the minimum thickness of deck plating (cols. 5 and 7) is to be modified at the rate of 0,5 mm. for every 100 mm. of difference.

3. **Stringer plates and angles.**—The thickness of stringer plates may be the same as that of the deck plating. Angles connecting the deck to shell plating are to have the same thickness as the stringer or deck plating to which they are attached.

4. **Sheathed decks.**—Where plated decks are sheathed with wood or approved composition the thickness given in cols. 5, 7 and 8 may be reduced by 10 per cent.

5. **Decks with stringer and tie plates.**—Stringer and tie plates fitted under a wood deck are to have the combined sectional area, for 0,4L amidships, required for a plated deck.

The width of stringer plates from shell to inner edge, for 0,4L amidships, is not to be less than 965 mm. and 1170 mm. for lengths of 55 metres and 80 metres respectively with intermediate values in proportion. The width for 0,1L from the ends is not to be less than 60 per cent of the width amidships.

The width of tie plates throughout is not to be less than 300 mm. and 500 mm. for lengths of 55 metres and 80 metres respectively with intermediate values in proportion.

The thickness of the stringer and tie plates throughout is not to be less than given in col. 5.

# TABLE 21 SHORT SUPERSTRUCTURES

| LENGTH L | SIDE PLATING | | WIDTH OF STRINGER AND TIE PLATES WITH WOOD DECK | | THICKNESS OF STRINGER AND TIE PLATES WITH WOOD DECK | | | MINIMUM THICKNESS OF UNSHEATHED PLATED DECKS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | POOP | BRIDGE & FORECASTLE | STRINGER | TIE PLATE | POOP | BRIDGE | FORECASTLE | POOP | BRIDGE | FORECASTLE | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
| Metres | mm. | mm. | mm. | mm. | mm. | mm. | mm. | mm. | mm. | mm. | |
| **30** | 5,5 | 5,5 | 300 | 125 | 5,5 | 5,5 | 5,5 | 6 | 6 | 6 | |
| **35** | 5,5 | 5,5 | 340 | 125 | 5,5 | 5,5 | 5,5 | 6 | 6 | 6 | |
| **40** | 5,5 | 5,5 | 385 | 130 | 5,5 | 5,5 | 5,5 | 6 | 6 | 6 | |
| **45** | 6 | 6 | 425 | 140 | 6 | 6 | 6 | 6 | 6 | 6 | |
| **50** | 6 | 6,5 | 470 | 150 | 6 | 6,5 | 6,5 | 6,5 | 6,5 | 6,5 | |
| **55** | 6,5 | 7 | 510 | 160 | 6,5 | 7 | 7 | 6,5 | 6,5 | 6,5 | |
| **60** | 6,5 | 7 | 550 | 165 | 6,5 | 7 | 7 | 6,5 | 6,5 | 6,5 | |
| **65** | 6,5 | 7 | 595 | 175 | 6,5 | 7 | 7 | 6,5 | 6,5 | 6,5 | |
| **70** | 7 | 7,5 | 635 | 185 | 7 | 7,5 | 7,5 | 6,5 | 6,5 | 6,5 | |
| **75** | 7 | 7,5 | 670 | 190 | 7 | 7,5 | 7,5 | 6,5 | 7 | 7 | |
| **80** | 7,5 | 8 | 700 | 200 | 7,5 | 8 | 8 | 6,5 | 7 | 7 | |
| **85** | 7,5 | 8,5 | 730 | 205 | 7,5 | 8,5 | | 7 | 7 | 7 | ^ |
| **90** | 8 | 8,5 | 760 | 210 | 8 | 8,5 | | 7 | 7 | 7 | \| |
| **95** | 8 | 9 | 795 | 220 | 8 | 9 | | 7 | 7 | 7 | \| |
| **100** | 8 | 9 | 815 | 225 | 8 | 9 | | 7 | 7,5 | 7,5 | \| |
| **105** | 8,5 | 9,5 | 835 | 230 | 8,5 | 9,5 | | 7 | 7,5 | 7,5 | \| |
| **110** | 8,5 | 9,5 | 860 | 240 | 8,5 | 9,5 | | 7 | 7,5 | 7,5 | \| |
| **115** | 9 | 10 | 880 | 245 | 9 | 10 | | 7 | 7,5 | 7,5 | \| |
| **120** | 9 | 10 | 900 | 250 | 9 | 10 | | 7 | 7,5 | 7,5 | \| |
| **125** | 9 | 10 | 920 | 255 | 9 | | | 7 | 8 | 8 | \| |
| **130** | 9,5 | 10,5 | 940 | 260 | 9,5 | | | 7,5 | 8 | 8 | \| |
| **135** | 9,5 | 10,5 | 960 | 265 | 9,5 | | | 7,5 | 8 | 8 | \| |
| **140** | 10 | 11 | 980 | 270 | 10 | | | 7,5 | 8 | 8 | \| |
| **145** | 10 | 11 | 1005 | 275 | 10 | | | 7,5 | 8,5 | 8,5 | \| |
| **150** | 10,5 | 11,5 | 1025 | 280 | 10,5 | | | 7,5 | 8,5 | 8,5 | \| |
| **155** | 10,5 | 11,5 | 1045 | 285 | 10,5 | | | 7,5 | 8,5 | 8,5 | \| |
| **160** | 10,5 | 11,5 | 1065 | 290 | 10,5 | | | 7,5 | 8,5 | 8,5 | \| |
| **165** | 11 | 12 | 1085 | 295 | 11 | | | 8 | 8,5 | 8,5 | \| |
| **170** | 11 | 12 | 1105 | 300 | 11 | | | 8 | 9 | 9 | \| |
| **175** | 11,5 | 12,5 | 1130 | 300 | 11,5 | | | 8 | 9 | 9 | \| |
| **180** | 11,5 | 12,5 | 1150 | 300 | 11,5 | | | 8 | 9 | 9 | \| |
| **185** | 11,5 | 12,5 | 1170 | 300 | 11,5 | | | 8 | 9 | 9 | \| |
| **190** | 12 | 13 | 1190 | 300 | 12 | | | 8 | 9 | 9 | \| |
| **195** | 12 | 13 | 1210 | 300 | 12 | | | 8 | 9,5 | 9,5 | \| |
| **200** | 12 | 13 | 1235 | 300 | 12 | | | 8 | 9,5 | 9,5 | v |

PLATED DECK REQUIRED

PLATED DECK REQUIRED

# SHORT SUPERSTRUCTURES

**NOTES.—TABLE 21**

1. **Sheathed decks.**—Where plated decks are sheathed with wood or approved composition the thickness given in cols. 9, 10 and 11 may be reduced by 10 per cent.

2. **Allowance for height of platform.**—If the draught desired is not greater than 0,7D (D being measured to the uppermost continuous deck) all thicknesses given in the Table may be reduced by 10 per cent.

3. **Stringer angles.**—Angles connecting the deck to shell plating are to have the same thickness as required for plated decks, cols. 9, 10 and 11.

# TABLE 22 END BULKHEADS OF SUPERSTRUCTURES

Stiffeners spaced 760 mm. apart

## BULKHEADS AT THE FORE END OF BRIDGES, OF UNPROTECTED POOPS THE LENGTH OF WHICH IS 0,4L OR MORE AND OF ALL POOPS PROTECTING MACHINERY OPENINGS

| LENGTH L | BULB ANGLE STIFFENERS | RIVETS IN END LUGS | | PLATING |
|---|---|---|---|---|
| | | Number | Diameter | |
| Metres | Millimetres<br>*Modulus—centimetres³* | | Millimetres | Millimetres |
| Under 48,8 | 149 × 65 × 8,5<br>*91,8* | 3 | 16 | 7,5 |
| 48,8 | 150 × 75 × 9<br>*114* | 3 | 16 | 7,5 |
| 60 | 165 × 75 × 8,5<br>*132* | 4 | 16 | 7,5 |
| 70 | 180 × 75 × 8<br>*158* | 4 | 16 | 8 |
| 80 | 180 × 75 × 10,5<br>*183* | 4 | 19 | 9 |
| 90 | 200 × 75 × 9<br>*211* | 4 | 19 | 9,5 |
| 100 | 200 × 75 × 11<br>*243* | 5 | 19 | 10 |
| 110 | *278* | 5 | 19 | 10,5 |
| 120 | 230 × 90 × 11<br>*308* | 5 | 19 | 11 |
| 130 | 230 × 90 × 12<br>*343* | 5 | 19 | 11 |
| 140 | *382* | 5 | 19 | 11 |
| 150 | 250 × 90 × 12<br>*424* | 5 | 19 | 11 |
| 160 | *472* | 6 | 19 | 11 |
| 170 | 280 × 90 × 12<br>*518* | 6 | 19 | 11 |

## BULKHEADS OF POOPS PARTIALLY PROTECTED OR LESS IN LENGTH THAN 0,4L AND NOT PROTECTING MACHINERY OPENINGS

| LENGTH L | ANGLE STIFFENERS | RIVETS IN END LUGS | | PLATING |
|---|---|---|---|---|
| | | Number | Diameter | |
| Metres | Millimetres<br>*Modulus—centimetres³* | | Millimetres | Millimetres |
| Under 45,75 | 75 × 65 × 7,5<br>*16,4* | 2 | 16 | 6 |
| 45,75 | 90 × 65 × 8<br>*23* | 2 | 16 | 6 |
| 60 | 100 × 75 × 8,5<br>*30,5* | 2 | 16 | 6,5 |
| 75 | 120 × 75 × 8,5<br>*40,5* | 2 | 16 | 7,5 |
| 90 | 130 × 75 × 9<br>*50,5* | 3 | 16 | 8 |
| 105 | 150 × 75 × 9<br>*67* | 3 | 16 | 8,5 |
| 120 | 150 × 75 × 11,5<br>*83* | 3 | 19 | 9,5 |
| 135 | 180 × 90 × 10<br>*101* | 3 | 19 | 9,5 |
| 150 | 180 × 90 × 11,5<br>*120* | 4 | 19 | 9,5 |
| 165 | 180 × 90 × 12,5<br>*127* | 4 | 19 | 9,5 |

## BULKHEADS AT AFTER ENDS OF BRIDGES AND FORECASTLES

| LENGTH L | ANGLE STIFFENERS | PLATING |
|---|---|---|
| Metres | Millimetres<br>*Modulus—centimetres³* | Millimetres |
| Under 45,75 | 65 × 65 × 6,5<br>*9,8* | 5 |
| 45,75 | 75 × 65 × 7<br>*14,8* | 5 |
| 75 | 90 × 75 × 7,5<br>*21* | 6 |
| 105 | 100 × 75 × 8<br>*29* | 7 |
| 120 | 100 × 75 × 10<br>*35* | 7,5 |
| 122 and above | 100 × 75 × 10,5<br>*36,1* | 7,5 |

Stiffeners to overlap, and be riveted to, boundary angles

## NOTES.—TABLE 22

1. **Correction for spacing of stiffeners.**—If the spacing of stiffeners differs from 760 mm., modulus of stiffeners is to be modified in direct proportion.

If the spacing of the stiffeners is greater than 760 mm., the thickness of plating is to be increased at the rate of 0,5 mm. for every 100 mm. increase in spacing.

2. **Allowance for height of platform.**—When the draught d does not exceed 0,7D, D being measured to the uppermost continuous deck, the scantlings given in the Table may be modified as follows :—

THICKNESS OF PLATING.

Where L = 60 metres or less, thickness may be 90 per cent of Table thickness.

Where L = 120 metres or above, thickness may be 85 per cent of Table thickness.

MODULUS OF STIFFENERS.

Where L = 60 metres or less, modulus may be 75 per cent of Table modulus.

Where L = 120 metres or above, modulus may be 70 per cent of Table modulus.

For intermediate lengths the percentage may be obtained by interpolation.

3. Bulkheads at the fore ends of bridges which do not cover deck openings are to have plating as required by the Table, but the modulus of the stiffeners may be reduced by 10 per cent.

4. Particulars of sections and moduli are given in Table 56.

# DECKHOUSES

TABLE 23
*(SEE CONTINUATION)*

## LOWER TIER

Stiffeners spaced 760 mm. apart

| LENGTH L | FRONTS | | | SIDES | | | CORRECTION PER 0,3 METRE DIFFERENCE IN DRAUGHT (*See* NOTE 1) | |
|---|---|---|---|---|---|---|---|---|
| | STIFFENERS | | PLATING | STIFFENERS | | PLATING | STIFFENERS | PLATING |
| Metres | ANGLES | Millimetres *Modulus—centimetres*³ | Millimetres | ANGLES | Millimetres *Modulus—centimetres*³ | Millimetres | Per Cent | Per Cent |
| 60 | | 100 × 75 × 10,5 *36,5* | 6,5 | | 90 × 75 × 8 *22,7* | 6,5 | 10 | 6 |
| 90 | | 130 × 75 × 8,5 *47,8* | 7 | | 100 × 75 × 7,5 *26,8* | 6,5 | 25 | 8 |
| 120 | | 130 × 75 × 11 *61,1* | 7,5 | | 100 × 75 × 9 *32,2* | 7 | 40 | 10 |
| 150 | | 150 × 75 × 11,5 *84,5* | 8 | | 120 × 75 × 8,5 *42,5* | 7,5 | 50 | 11 |
| 180 | | *111* | 8,5 | | 140 × 75 × 8,5 *55,2* | 8 | 50 | 12 |

## UPPER TIER

Stiffeners spaced 760 mm. apart

| LENGTH L | FRONTS | | | SIDES | | | CORRECTION PER 0,3 METRE DIFFERENCE IN DRAUGHT (*See* NOTE 1) | |
|---|---|---|---|---|---|---|---|---|
| | STIFFENERS | | PLATING | STIFFENERS | | PLATING | STIFFENERS | PLATING |
| Metres | ANGLES | Millimetres *Modulus—centimetres*³ | Millimetres | ANGLES | Millimetres *Modulus—centimetres*³ | Millimetres | Per Cent | Per Cent |
| 60 | | 75 × 65 × 6,5 *13,8* | 6 | | 65 × 65 × 6,5 *11,4* | 6 | 10 | 5 |
| 90 | | 75 × 65 × 8,5 *17,9* | 6 | | 75 × 65 × 7 *14,5* | 6 | 15 | 6 |
| 120 | | 90 × 75 × 7,5 *22,5* | 6,5 | | 75 × 75 × 9 *19,2* | 6 | 20 | 7 |
| 150 | | 100 × 75 × 8,5 *30,3* | 7 | | 90 × 75 × 8,5 *24,9* | 6,5 | 25 | 8 |
| 180 | | 120 × 75 × 8 *40,0* | 7,5 | | 100 × 75 × 9 *32,0* | 7 | 30 | 9 |

*For notes see page 121*

# TABLE 23
(CONTINUATION)

## BEAMS WITH PLATED DECK

Spaced 760 mm. apart

| LENGTH L | SPAN METRES | | | | | |
|---|---|---|---|---|---|---|
| | 3 | | 4,5 | | 6 | |
| Metres | Millimetres *Modulus—centimetres*[3] | | | | | |
| 60 | ANGLES | 75 × 65 × 6,5 *13,9* | ANGLES | 100 × 75 × 9 *31,5* | BULB ANGLES | 140 × 75 × 8,5 *55,5* |
| 90 | | 90 × 75 × 7 *21,0* | | 120 × 75 × 8 *40,1* | | 150 × 75 × 9 *64,7* |
| 120 | | 100 × 75 × 8 *27,3* | | 130 × 75 × 8,5 *48,6* | | 140 × 65 × 7 *80,8* |
| 150 | | 100 × 75 × 9 *32,0* | | 130 × 75 × 10 *57,7* | | 140 × 65 × 8,5 *89,5* |
| 180 | | 120 × 75 × 8 *40,5* | | 150 × 75 × 9 *68,1* | | 150 × 75 × 7,5 *99,1* |

## DECK PLATING

### ABOVE DECKHOUSES

| LENGTH L | AREA OF DECK ABOVE LONG HOUSES—PERCENTAGE OF DECK AREA OF STRENGTH DECK ASSUMING TWO DECKS FITTED | MINIMUM THICKNESS OF DECK PLATING (*See* NOTE 9) | |
|---|---|---|---|
| | | UNSHEATHED | SHEATHED |
| 1 | 2 | 3 | 4 |
| Metres | Per Cent | Millimetres | Millimetres |
| 60 | 60 | 6 | 5 |
| 90 | 50 | 6,5 | 5,5 |
| 120 | 40 | 6,5 | 6 |
| 150 | 35 | 7 | 6 |
| 165 | 30 | 7,5 | 6,5 |

*For notes see page 121*

## NOTES.—TABLE 23

1. **Draught.**—The Table is directly applicable when the ratio d/D = 0,70, D being measured to the deck upon which the lowest tier of deckhouses is situated.

If the draught is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than that corresponding to the above ratio the modulus of the stiffeners and the thickness of the plating of the deckhouse fronts and sides are to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ by the percentages given in this Table, subject to a maximum increase of 100 per cent and a maximum reduction of 20 per cent in modulus and subject to a maximum reduction of 10 per cent in the thickness of the plating.

2. **Spacing of stiffeners.**—If the spacing of the stiffeners differs from 760 mm., the modulus of the stiffeners is to be modified in direct proportion. The thickness of the plating is to be increased at the rate of 0,5 mm. for every 150 mm. increase in spacing.

3. **Single tier deckhouses.**—For deckhouses not having an upper tier of houses the modulus of stiffeners of the sides and aft end may, after correction for draught, be reduced by 15 per cent except where d/D exceeds 0,70.

4. **Breadth of deckhouse fronts.**—The Table is directly applicable, subject to the above corrections, to deckhouse fronts which are 0,75B or more in breadth.

When the breadth of a partially protected house front is 0,25B or less, the scantlings may be as required for sides; when the breadth is intermediate between these limits the scantlings may be obtained by interpolation.

5. **Flush deck ships, and those with forecastles, or forecastles and poops, having minimum freeboards.**—The modulus of stiffeners at the fronts of houses in these ships is, after correction, to be increased by 100 per cent, and two webs are to be arranged.

The corrected thickness of the front plating is to be increased 5 per cent.

6. **After ends of houses.**—The modulus of the stiffeners is to be 70 per cent of that of the side stiffeners and the thickness of the plating is to be 90 per cent of that of the side plating based on 760 mm. spacing. Unprotected deckhouses at after ends of ships will be specially considered.

7. **End connections of stiffeners.**—Stiffeners at fronts of deckhouses are to be lugged except at the upper tier when L is less than 152 metres. Stiffeners at sides of lower tier are to be bracketed if there are two tiers, and lugged if there is only one tier; those at upper tiers are to be lugged when L exceeds 152 metres. Stiffeners at aft ends of deckhouses may be unattached. If stiffeners are welded to the deck, brackets may be omitted, provided the section modulus of the stiffeners is increased by 20 per cent.

8. **Beams.**—The Table is directly applicable to the beams of a lower deckhouse having superimposed houses. If there are no superimposed houses the modulus of the beam may be reduced by 20 per cent.

The modulus of the beams of the upper tier may be 20 per cent less than required by the Table and if there is a third tier the beams of that tier may be 40 per cent less than required by the Table.

If the beam spacing differs from 760 mm. the modulus of the beams is to be modified in direct proportion.

9. **Deck plating above houses.**—Where the length of a deckhouse exceeds 0,15L, deck plating of the sectional area derived from the Table is to be fitted at the top of the house.

The two decks referred to in col. 2 are the decks of the main hull as used in Table 18.

If there are two tiers of houses the sectional area of the top of each may be 80 per cent of the area derived from the Table, or alternatively the top of the upper tier may be 75 per cent, and of the lower tier 100 per cent of that area.

The minimum thicknesses of plating given in cols. 3 and 4 apply to decks outside deckhouses and outside line of openings; within the line of openings the thicknesses may be reduced by 10 per cent. Inside deckhouses the thicknesses may be reduced by a further 10 per cent.

The thickness of unsheathed plating (col. 3) is to be increased by 0,5 mm. for each 150 mm. increase of spacing above 915 mm.

10. Where the height of deckhouses exceeds 2,75 metres the scantlings will be specially considered.

11. **Exposed machinery casings.**—The thickness of the plating and the modulus of the stiffeners are to be 20 per cent greater than those for deckhouses in the same position.

12. Particulars of sections and moduli are given in Table 56.

# TABLE 24

## BEAMS AT

| BREADTH B | BEAM SPACING | CORRECTION FACTOR K | UNSUPPORTED SPAN METRES | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 2 | 2,5 | 3 | 3,5 | 4 | 4,5 | 5 |
| Metres | Millimetres | | Millimetres³ *Modulus—centimetres* | | | | | | |
| 7 | 525 | 1,20 | 75×65×8 *17,0* | 75×65×9,5 *20,0* | 90×75×8 *23,0* | 90×75×9 *26,0* | 100×75×8,5 *30,0* | | |
| 8 | 550 | 1,20 | 75×65×9 *19,0* | 90×75×7,5 *22,0* | 90×75×8,5 *25,0* | 90×75×9,5 *28,5* | 100×75×9,5 *33,0* | | |
| 9 | 570 | 1,20 | 90×75×7,5 *21,5* | 90×75×8,5 *24,5* | 90×75×9,5 *28,0* | 100×75×9 *32,0* | 100×75×10,5 *36,0* | 100×75×12 *41,5* | |
| 10 | 590 | 1,20 | 90×75×8,5 *25,0* | 90×75×9,5 *28,0* | 100×75×9 *32,0* | 100×75×10,5 *36,0* | 100×75×12 *41,5* | 120×75×10 *48,0* | 120×75×11,5 *55,0* |
| 11 | 610 | 1,20 | | 100×75×10 *35,0* | 100×75×11 *39,0* | 120×75×9 *44,0* | 120×75×10,5 *51,0* | 150×75×8 *59,0* | 150×75×9,5 *69,0* |
| 12 | 630 | 1,20 | | 120×75×9,5 *45,5* | 120×75×10,5 *50,0* | 120×75×11,5 *56,0* | 150×75×8,5 *63,5* | 150×75×10 *74,0* | 150×75×12 *87,5* |
| 13 | 650 | 1,20 | | | 150×75×9 *65,0* | 150×75×9,5 *71,0* | 150×75×11 *80,0* | 150×75×12,5 *92,0* | 150×75×8,5 *106* |
| 14 | 675 | 1,20 | | | 150×75×11,5 *85,0* | *94,0* | 150×75×8 *104* | 150×75×9,5 *117* | 165×75×8,5 *132* |
| 15 | 695 | 1,20 | | | 150×75×8,5 *106* | 150×75×9,5 *117* | 165×75×8,5 *129* | 165×75×10 *144* | 180×90×8,5 *161* |
| 16 | 715 | 1,19 | | | *131* | *144* | 180×90×8 *157* | 180×90×9,5 *172* | 180×90×11 *188* |
| 17 | 735 | 1,16 | | | | 180×90×9,5 *171* | 180×90×10,5 *184* | 180×90×11,5 *199* | *216* |
| 18 | 755 | 1,13 | | | | 180×90×11,5 *196* | *210* | 200×90×10 *226* | 200×90×11,5 *243* |
| 19 | 775 | 1,10 | | | | *223* | 200×90×11 *237* | 200×90×12 *253* | 200×90×13 *271* |
| 20 | 800 | 1,06 | | | | 200×90×11,5 *246* | 200×90×12,5 *261* | *278* | *297* |
| 21 | 820 | 1,03 | | | | *266* | *282* | *301* | 230×90×11 *321* |
| 22 | 840 | 1,00 | | | | *281* | *300* | 230×90×11 *320* | 230×90×12 *342* |
| 23 | 860 | 1,00 | | | | *293* | *313* | 230×90×11,5 *335* | 230×90×13 *359* |
| 24 | 880 | 1,00 | | | | *304* | 230×90×11 *325* | 230×90×12,5 *347* | *372* |

ANGLES

BULB ANGLES

### NOTES.—TABLE 24

1. **Application to various decks.**—(*a*) The modulus given in the Table applies to weather deck beams in ships having a ratio of d/D not exceeding 0,7 (D being measured to the uppermost continuous deck) with the exception of the following :—

(1) Single deck ships – – – (*see* (*d*))
(2) Short bridges and poops – – (*see* (*f*))
(3) Forecastle decks – – – (*see* (*g*))
(4) The forward 0,12L of weather decks – (*see* (*g*))

(*b*) When d/D is 0,85 or greater the modulus for weather deck beams (except as qualified by (*d*) to (*g*)) is to be the Table modulus multiplied by the factor K given in the third column.

(*c*) When d/D lies between 0,7 and 0,85 the correction factor is to be found by interpolation between 1,0 for d/D = 0,7 and the Table factor K for d/D = 0,85.

(*d*) **Single deck ships.** The modulus is to be obtained in accordance with the above notes and increased by 20 per cent.

(*e*) **Bridges forming an effective superstructure** as defined in D 206. The modulus is to be taken directly from the Table without the use of the factor K.

(*f*) **Short bridges and poops.** The modulus taken directly from the Table without the use of the factor K may be reduced by 30 per cent.

(*g*) **Forecastles and weather decks.** For the forward 0,075L the Table modulus is to be multiplied by the factor 1,2K irrespective of draught. Between 0,075L and 0,12L from forward, the Table modulus is to be multiplied

| UNSUPPORTED SPAN METRES | | | | | | | CORRECTION FACTOR K | BEAM SPACING | BREADTH B |
|---|---|---|---|---|---|---|---|---|---|
| 5,5 | 6 | 6,5 | 7 | 7,5 | 8 | | | | |
| Millimetres *Modulus—centimetres³* | | | | | | | | Millimetres | Metres |
| | | | | | | ANGLES | 1,20 | 525 | 7 |
| | | | | | | | 1,20 | 550 | 8 |
| | | | | | | | 1,20 | 570 | 9 |
| | | | | | | | 1,20 | 590 | 10 |
| 150 × 75 × 11<br>*82,0* | | | | | | | 1,20 | 610 | 11 |
| 150 × 75 × 8<br>*102* | 150 × 75 × 9,5<br>*118* | | | | | BULB ANGLES | 1,20 | 630 | 12 |
| 150 × 75 × 10<br>*122* | 165 × 75 × 9,5<br>*141* | 180 × 75 × 8,5<br>*164* | | | | | 1,20 | 650 | 13 |
| 165 × 75 × 10,5<br>*150* | 180 × 75 × 9<br>*170* | 180 × 75 × 11<br>*194* | *224* | | | | 1,20 | 675 | 14 |
| 180 × 90 × 10<br>*178* | 180 × 90 × 11,5<br>*198* | *220* | 200 × 90 × 11,5<br>*248* | | | | 1,20 | 695 | 15 |
| *206* | 200 × 90 × 10<br>*227* | 200 × 90 × 11,5<br>*250* | *279* | *308* | 230 × 90 × 12<br>*341* | | 1,19 | 715 | 16 |
| 200 × 90 × 10,5<br>*234* | 200 × 90 × 12<br>*255* | *280* | *309* | 230 × 90 × 12<br>*340* | *376* | | 1,16 | 735 | 17 |
| 200 × 90 × 12,5<br>*262* | *283* | *309* | 230 × 90 × 12<br>*340* | *374* | 250 × 90 × 11,5<br>*412* | | 1,13 | 755 | 18 |
| *291* | *314* | 230 × 90 × 12<br>*340* | *373* | 250 × 90 × 11,5<br>*409* | 250 × 90 × 13<br>*448* | | 1,10 | 775 | 19 |
| 230 × 90 × 11<br>*318* | 230 × 90 × 12<br>*342* | *371* | 250 × 90 × 11,5<br>*407* | 250 × 90 × 13<br>*445* | *487* | | 1,06 | 800 | 20 |
| 230 × 90 × 12<br>*343* | *370* | 250 × 90 × 11<br>*402* | 250 × 90 × 13<br>*440* | *480* | *523* | | 1,03 | 820 | 21 |
| *366* | *396* | 250 × 90 × 12,5<br>*430* | *470* | *509* | 280 × 90 × 12,5<br>*549* | | 1,00 | 840 | 22 |
| *384* | 250 × 90 × 11,5<br>*414* | 250 × 90 × 13,5<br>*448* | *489* | *528* | 280 × 90 × 13,5<br>*568* | | 1,00 | 860 | 23 |
| *398* | 250 × 90 × 12,5<br>*428* | 250 × 90 × 14<br>*464* | *506* | 280 × 90 × 12<br>*545* | 280 × 90 × 14<br>*586* | | 1,00 | 880 | 24 |

**NOTES.—TABLE 24** (*concluded*)

by the factor K, irrespective of draught.

2. **Span** for use in the Table is to be measured in metres from girder to girder or from girder to a point midway between the toe of the bracket and the inner edge of the frame.

3. **Corrections to modulus of beams.**

FOR BEAM SPACING.

If the spacing at any point differs from that given in the Table the modulus is to be modified in direct proportion.

FOR HANGING CARGOES.

If the beams carry hanging cargo, such as chilled beef, the modulus is to be increased by 50 and 100 per cent for one or two tiers respectively, but need not exceed the modulus of beams derived from Table 25 and note 3 to that Table.

FOR BEAMS WITHOUT PLATING.

Where a plated deck is not fitted the modulus of the beam is to be increased by 30 per cent for use in Table 56.

4. For width of faying flanges *see* D 3202.

5. Particulars of sections and moduli are given in Table 56.

6. **Timber Deck Cargoes.** Where timber load lines are to be assigned the Table Modulus is to be multiplied by the factor K, irrespective of draught. In single deck ships the increase of 20 per cent is to be applied.

# TABLE 25

## BEAMS AT CARGO AND

| BREADTH B | BEAM SPACING | CORRECTION FACTOR C | | UNSUPPORTED SPAN METRES 2 | 2,5 | 3 | 3,5 | 4 | 4,5 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|
| Metres | Millimetres | | | Millimetres — Modulus—centimetres³ | | | | | | |
| 7 | 525 | 0,50 | ANGLES | 75×65×10,5 *22,0* | 90×75×10,5 *31,0* | 100×75×11,5 *41,0* | 120×75×10,5 *51,0* | | | |
| 8 | 550 | 0,50 | ANGLES | 75×65×10,5 *22,0* | 90×75×11 *32,0* | 120×75× 9 *43,0* | 130×75× 9,5 *55,0* | 140×75×10,5 *67,0* | | |
| 9 | 570 | 0,50 | ANGLES | | 100×75× 9,5 *33,5* | 120×75× 9,5 *46,0* | 130×75×10,5 *59,0* | 150×75×10 *72,0* | *86,0* | |
| 10 | 590 | 0,50 | ANGLES | | 100×75×10 *35,5* | 120×75×10 *49,0* | 130×75×11,5 *64,0* | 150×75×11 *79,0* | 150×75× 7 *95,0* | |
| 11 | 610 | 0,50 | ANGLES | | 100×75×10,5 *37,5* | 120×75×11 *53,0* | 150×75× 9,5 *69,5* | 150×75×12 *87,0* | 150×75× 8,5 *107* | 165×75× 8,5 *129* |
| 12 | 630 | 0,50 | ANGLES | | 120×75× 8 *40,0* | 130×75×10 *57,0* | 150×75×10,5 *76,0* | 150×75× 7 *95,5* | 150×75×10 *119* | 165×75×10 *146* |
| 13 | 650 | 0,53 | ANGLES | | 120×75× 8,5 *42,5* | 130×75×11 *62,0* | 150×75×11,5 *83,5* | 150×75× 8,5 *106* | 165×75× 8,5 *132* | 180×75× 8,5 *164* |
| 14 | 675 | 0,57 | ANGLES | | 120×90× 9,5 *45,5* | 130×90×12 *68,0* | 150×90×12,5 *92,0* | *118* | *147* | 180×90×10,5 *183* |
| 15 | 695 | 0,62 | ANGLES | | 120×90×10 *48,0* | 150×90×10 *74,0* | 150×90×14 *101* | *129* | 180×90× 8,5 *162* | *201* |
| 16 | 715 | 0,66 | ANGLES | | 120×90×10,5 *51,0* | 150×90×11 *79,5* | 180×90×10,5 *110* | *142* | 180×90×10 *178* | *219* |
| 17 | 735 | 0,70 | BULB ANGLES | | | | *121* | 180×90× 8 *157* | 180×90×11,5 *196* | 200×90×11 *237* |
| 18 | 755 | 0,74 | BULB ANGLES | | | | *134* | 180×90× 9,5 *172* | *213* | 200×90×12 *255* |
| 19 | 775 | 0,78 | BULB ANGLES | | | | *149* | 180×90×10,5 *188* | 200×90×10,5 *230* | 200×90×13 *272* |
| 20 | 800 | 0,82 | BULB ANGLES | | | | 180×90× 9 *169* | *208* | 200×90×11,5 *250* | *291* |
| 21 | 820 | 0,86 | BULB ANGLES | | | | 180×90×11 *190* | 200×90×10 *228* | 200×90×13 *268* | *308* |
| 22 | 840 | 0,90 | BULB ANGLES | | | | | 200×90×12 *256* | *292* | 230×90×11 *328* |
| 23 | 860 | 0,90 | BULB ANGLES | | | | | | *316* | 230×90×12,5 *349* |
| 24 | 880 | 0,90 | BULB ANGLES | | | | | | 230×90×12 *342* | *370* |

### NOTES.—TABLE 25

1. **Application to various decks.**—(*a*) Cargo decks. The modulus of the beams is to be determined directly from the Table and corrected as required below.

(*b*) **Accommodation decks.** The modulus derived from (*a*) is to be multiplied by the factor C given in the third column of the Table.

2. **Span** for use in the Table is to be measured from girder to girder or from girder to a point midway between the toe of the bracket and the inner edge of the frame.

3. **Corrections to modulus of beams.**

FOR BEAM SPACING.

If the spacing at any point differs from the spacing given in the Table, modulus is to be modified in direct proportion.

# ACCOMMODATION DECKS

| UNSUPPORTED SPAN METRES 5,5 | 6 | 6,5 | 7 | 7,5 | 8 | | CORRECTION FACTOR C | BEAM SPACING | BREADTH B |
|---|---|---|---|---|---|---|---|---|---|
| Millimetres / Modulus—centimetres | | | | | | | | Millimetres | Metres |
| | | | | | | ANGLES | 0,50 | 525 | 7 |
| | | | | | | | 0,50 | 550 | 8 |
| | | | | | | | 0,50 | 570 | 9 |
| | | | | | | | 0,50 | 590 | 10 |
| | | | | | | | 0,50 | 610 | 11 |
| 165 × 75 × 10,5 *152* | | | | | | | 0,50 | 630 | 12 |
| 180 × 75 × 10 *179* | *212* | | | | | | 0,53 | 650 | 13 |
| *202* | 200 × 90 × 11 *240* | *279* | | | | | 0,57 | 675 | 14 |
| 200 × 90 × 10 *225* | 200 × 90 × 13 *268* | *311* | 230 × 90 × 13 *358* | | | | 0,62 | 695 | 15 |
| 200 × 90 × 11,5 *246* | *291* | 230 × 90 × 11,5 *336* | *388* | 250 × 90 × 13 *438* | | | 0,66 | 715 | 16 |
| 200 × 90 × 13 *265* | *310* | 230 × 90 × 13 *356* | 250 × 90 × 11,5 *407* | 250 × 90 × 14 *458* | *510* | BULB ANGLES | 0,70 | 735 | 17 |
| *283* | 230 × 90 × 11,5 *328* | *375* | 250 × 90 × 12 *426* | *476* | *532* | | 0,74 | 755 | 18 |
| *300* | 230 × 90 × 12 *345* | *392* | 250 × 90 × 13 *443* | *494* | 280 × 90 × 12,5 *549* | | 0,78 | 775 | 19 |
| *317* | 230 × 90 × 13 *361* | 250 × 90 × 11,5 *407* | 250 × 90 × 14 *458* | *509* | 280 × 90 × 13 *566* | | 0,82 | 800 | 20 |
| 230 × 90 × 11,5 *334* | *377* | 250 × 90 × 12 *423* | *474* | *526* | 280 × 90 × 14 *583* | | 0,86 | 820 | 21 |
| 230 × 90 × 12,5 *350* | *391* | 250 × 90 × 12,5 *437* | *487* | 280 × 90 × 12 *540* | 280 × 90 × 14,5 *598* | | 0,90 | 840 | 22 |
| *368* | 250 × 90 × 11,5 *409* | 250 × 90 × 13,5 *454* | *505* | 280 × 90 × 13 *558* | *616* | | 0,90 | 860 | 23 |
| *385* | 250 × 90 × 12 *425* | 250 × 90 × 14 *468* | *520* | 280 × 90 × 13,5 *574* | *632* | | 0,90 | 880 | 24 |
| 250 × 90 × 11 *402* | 250 × 90 × 13 *441* | *484* | *535* | 280 × 90 × 14 *589* | *649* | | | | |

## NOTES.—TABLE 25 (*concluded*)

FOR 'TWEEN DECK HEIGHT.

If the 'tween deck height in cargo spaces differs from 2,6 metres, modulus is to be modified in direct proportion.

FOR HANGING CARGOES.

If the beams carry hanging cargo, such as chilled beef, and may be simultaneously loaded above with cargo, the modulus is to be increased by 30, 60 and 90 per cent of the beam modulus required for a 2,6 metres 'tween deck for, one two or three tiers respectively. For accommodation decks the increase in the modulus for hanging cargo is to be the same as required above for cargo decks.

FOR BEAMS WITHOUT PLATING.

Where a plated deck is not fitted, the modulus of the beam is to be increased by 30 per cent for use in Table 56.

4. For width of faying flanges *see* D 3202.

5. Particulars of sections and moduli are given in Table 56.

# TABLE 26

## LONGITUDINALS AT WEATHER DECKS

| LENGTH L | SPACING OF LONGITUDINALS | CORRECTION FACTOR K | UNSUPPORTED SPAN METRES | | | | |
|---|---|---|---|---|---|---|---|
| | | | 2 | 2,5 | 3 | 3,5 | |
| Metres | Millimetres | | Millimetres *Modulus—centimetres³* | | | | |
| 50 | 705 | 1,20 | 120×75× 9,5 *46,5* | 130×75× 9,5 *55* | | | ANGLES |
| 55 | 715 | 1,20 | 120×75×10 *49* | 130×75×10 *57,5* | | | |
| 60 | 725 | 1,20 | 130×75× 9 *51,5* | 130×75×10,5 *60* | | | |
| 65 | 735 | 1,20 | 130×75× 9,5 *54* | 130×75×11 *62,5* | | | |
| 70 | 745 | 1,20 | 130×75×10 *57* | 130×75×11,5 *65* | | | |
| 75 | 755 | 1,20 | 130×75×10,5 *59,7* | 130×75×12 *66,9* | | | |
| 80 | 765 | 1,20 | 130×75×11 *62,5* | 150×75× 9,5 *70,4* | | | |
| 85 | 775 | 1,20 | 130×75×11,5 *65* | 150×75×10 *73* | 150×75×11 *81,2* | | |
| 90 | 785 | 1,20 | 140×75×10,5 *67,6* | 150×75×10,5 *76,4* | *84,1* | *94,1* | BULB ANGLES |
| 95 | 795 | 1,20 | 150×75× 9,5 *71* | 150×75×11 *82,4* | *92,7* | 150×75× 8 *105* | |
| 100 | 805 | 1,20 | 150×75×10 *75* | *89,2* | 150×75× 8 *103* | 150×75× 9,5 *118* | |
| 105 | 815 | 1,20 | 150×75×10,5 *79* | 150×75× 7 *96,5* | 150×75× 9 *114* | 165×75× 8,5 *131* | |
| 110 | 825 | 1,20 | 150×75×11 *82,8* | 150×75× 8 *103* | 150×75×10,5 *124* | 165×75×10 *145* | |
| 115 | 835 | 1,18 | *86,8* | 150×75× 8,5 *110* | 165×75× 8,5 *134* | 180×90× 8 *158* | |
| 120 | 845 | 1,17 | *90,8* | 150×75× 9,5 *118* | 165×75×10 *144* | 180×90× 9 *171* | |
| 125 | 855 | 1,15 | *94,5* | 150×75×10,5 *125* | 165×75×10,5 *154* | 180×90×10,5 *185* | |
| 130 | 865 | 1,13 | | 165×75× 8,5 *132* | 180×90× 8,5 *165* | 180×90×11,5 *198* | |
| 135 | 875 | 1,12 | | 165×75× 9 *139* | 180×90× 9,5 *174* | *211* | |
| 140 | 885 | 1,10 | | 165×75×10 *145* | 180×90×10,5 *185* | *224* | |
| 145 | 895 | 1,08 | | 165×75×10,5 *152* | 180×90×11 *195* | 200×90×11 *238* | |
| 150 | 905 | 1,07 | | 180×90× 8 *159* | *205* | 200×90×11,5 *252* | |
| 155 | 915 | 1,05 | | 180×90× 9 *166* | *215* | 200×90×12,5 *265* | |

*For notes see page 127*

## NOTES.—TABLE 26

1. **Application to various decks.**—(*a*) The modulus given in the Table applies to weather deck longitudinals, outside the line of deck openings, in ships having a ratio of d/D not exceeding 0,7 (D being measured to the uppermost continuous deck) with the exception of the following : —

Short bridges ... ... ... (*see* (*e*))

(*b*) When d/D is 0,85 or greater the modulus for weather deck longitudinals (except as qualified by (*d*) to (*h*)) is to be the Table modulus multiplied by the factor K given in the third column.

(*c*) When d/D lies between 0,7 and 0,85 the correction factor is to be found by interpolation between 1,0 for d/D=0,7 and the Table factor K for d/D=0,85.

(*d*) **Bridges forming an effective superstructure** as defined in D 206. The modulus is to be taken directly from the Table without the use of the factor K.

(*e*) **Short bridges.** The modulus taken directly from the Table without the use of the factor K may be reduced by 30 per cent.

(*f*) Outside the line of openings the modulus derived as above is to be maintained for 0,4L amidships and may be gradually reduced to 70 per cent of the midships value at 0,1L from the after end and to 85 per cent at 0,12L from the fore end.

(*g*) Within the line of openings abaft 0,12L from forward the modulus may be 70 per cent of that required outside the line of openings amidships.

(*h*) For the forward 0,075L of forecastles and weather decks, the Table modulus is to be multiplied by the factor 1,2K irrespective of draught. Between 0,075L and 0,12L from forward the Table modulus is to be multiplied by the factor K irrespective of draught.

2. **Span** for use in the Table is to be measured from transverse to transverse or from transverse to a point midway between the toe of the end bracket and the bulkhead.

3. **Corrections to modulus of longitudinals.**

FOR SPACING OF LONGITUDINALS.

If the spacing at any point differs from the spacing given in the Table, modulus is to be modified in direct proportion.

FOR HANGING CARGOES.

If the longitudinals carry hanging cargo, such as chilled beef, the modulus is to be increased by 50 and 100 per cent for one or two tiers, respectively, but need not exceed the modulus of longitudinals derived from Table 27 and note 3 to that Table.

4. For width of faying flanges *see* D 3202.

5. Particulars of sections and moduli are given in Table 56.

# TABLE 27

## LONGITUDINALS AT CARGO AND ACCOMMODATION DECKS

| LENGTH L | SPACING OF LONGITUDINALS | CORRECTION FACTOR C | UNSUPPORTED SPAN METRES 2 | 2,5 | 3 | 3,5 | |
|---|---|---|---|---|---|---|---|
| Metres | Millimetres | | Millimetres *Modulus—centimetres³* | | | | |
| 50 | 705 | 0,50 | 100 × 75 × 8 *29* | 120 × 75 × 8,5 *42* | | | ANGLES |
| 55 | 715 | 0,50 | 100 × 75 × 8,5 *31* | 120 × 75 × 9 *44* | | | |
| 60 | 725 | 0,50 | 100 × 75 × 9 *33* | 120 × 75 × 9,5 *46* | | | |
| 65 | 735 | 0,50 | 100 × 75 × 10 *35,5* | 120 × 75 × 10 *48,5* | | | |
| 70 | 745 | 0,50 | 100 × 75 × 10,5 *38* | 120 × 75 × 10,5 *51* | | | |
| 75 | 755 | 0,50 | 120 × 75 × 8 *41* | 120 × 75 × 11 *54* | | | |
| 80 | 765 | 0,50 | 120 × 75 × 9 *44,5* | 130 × 75 × 10 *56,7* | | | |
| 85 | 775 | 0,50 | 120 × 75 × 9,5 *47,6* | 130 × 75 × 10,5 *60,2* | 150 × 75 × 10 *73,2* | | |
| 90 | 785 | 0,54 | 130 × 75 × 9 *52,1* | 140 × 75 × 10 *64,6* | 150 × 75 × 10,5 *77,1* | *91,1* | ANGLES |
| 95 | 795 | 0,58 | 130 × 75 × 10 *56,8* | 150 × 75 × 9,5 *69,8* | *83,1* | 150 × 75 × 7 *97,1* | |
| 100 | 805 | 0,61 | 140 × 75 × 9,5 *61,7* | 150 × 75 × 10 *75,3* | *89,0* | 150 × 75 × 8 *104* | |
| 105 | 815 | 0,63 | 140 × 75 × 10 *66,6* | 150 × 75 × 11 *81,0* | *95,0* | *111* | |
| 110 | 825 | 0,65 | 150 × 75 × 9,5 *71,6* | *86,3* | 150 × 75 × 7,5 *101* | 150 × 75 × 9,5 *117* | |
| 115 | 835 | 0,67 | 150 × 75 × 10,5 *76,6* | *91,9* | 150 × 75 × 8,5 *107* | 150 × 75 × 10,5 *124* | |
| 120 | 845 | 0,69 | 150 × 75 × 11 *81,4* | 150 × 75 × 7 *97,2* | 150 × 75 × 9 *113* | *130* | |
| 125 | 855 | 0,71 | *86,0* | 150 × 75 × 8 *103* | 150 × 75 × 10 *120* | 165 × 75 × 9 *137* | BULB ANGLES |
| 130 | 865 | 0,73 | | 150 × 75 × 8,5 *109* | 150 × 75 × 10,5 *126* | 165 × 75 × 9,5 *143* | |
| 135 | 875 | 0,75 | | 150 × 75 × 9 *113* | 165 × 75 × 8,5 *131* | 165 × 75 × 10 *149* | |
| 140 | 885 | 0,77 | | 150 × 75 × 9,5 *119* | 165 × 75 × 9 *137* | 180 × 90 × 8 *156* | |
| 145 | 895 | 0,79 | | 150 × 75 × 10,5 *124* | 165 × 75 × 9,5 *143* | 180 × 90 × 8,5 *162* | |
| 150 | 905 | 0,81 | | *130* | *149* | 180 × 90 × 9 *169* | |
| 155 | 915 | 0,84 | | *136* | 180 × 90 × 8 *156* | 180 × 90 × 9,5 *176* | |

*For notes see page 129*

## NOTES.—TABLE 27

1. **Application to various decks.**—(*a*) For all cargo decks the modulus of the deck longitudinals is to be determined directly from the Table and corrected as required below.

(*b*) **Accommodation decks.** The modulus derived from (*a*) is to be multiplied by the factor C given in the third column of the Table.

2. **Span** for use in the Table is to be measured from transverse to transverse or from transverse to a point midway between the toe of the end bracket and the bulkhead.

3. **Corrections to modulus of longitudinals**

FOR SPACING OF LONGITUDINALS.

If the spacing at any point differs from the spacing given in the Table modulus is to be modified in direct proportion.

FOR 'TWEEN DECK HEIGHT.

If the 'tween deck height in cargo spaces differs from 2,6 metres modulus is to be modified in direct proportion.

FOR HANGING CARGOES.

If the longitudinals carry hanging cargo, such as chilled beef, and may be simultaneously loaded above with cargo, the modulus is to be increased by 30, 60 and 90 per cent of the modulus of longitudinal required for a 2,6 metres 'tween deck for one, two or three tiers respectively. For accommodation decks the increase in the modulus for hanging cargo is to be the same as required above for cargo decks.

4. For width of faying flanges *see* D 3202.

5. Particulars of sections and moduli are given in Table 56.

# TABLE 28

(SEE CONTINUATION)

## BEAM KNEES AND END BRACKETS OF DECK LONGITUDINALS

1. **Beam knees.** At decks where the hold frames terminate, and at the lower deck in the panting region, the dimensions of beam knees are to be based on the modulus of frame or beam, whichever is greater. At all other decks, except as indicated in 5 below, the dimensions are to be based on the modulus of the beam.

Knees are to be flanged when the modulus exceeds 590 cm.$^3$ and the width of the flange in millimetres is not to be less than $2{,}09\sqrt{\text{modulus}}$ with a minimum of 50 mm.

The thickness in millimetres of unflanged knees is not to be less than $4 + 0{,}314\sqrt{\text{modulus}}$ and of flanged knees $2 + 0{,}314\sqrt{\text{modulus}}$ with a minimum of 7 mm.

2. **Riveted beam knees.**

(*a*) Rivet diameter, d, is to be based on modulus as follows:—

| Modulus—cm.$^3$ | d—mm. |
|---|---|
| Below 115 | 16 |
| 115 – 295 | 19 |
| Above 295 | 22 |

(*b*) The number of rivets, N, in each overlap is not to be less than $1 + \frac{\sqrt{\text{modulus}}}{4}$ to the nearest whole number with a minimum of four. Rivets are not to be spaced less than $3\frac{1}{2}$ diameters nor more than 7 diameters apart.

(*c*) The minimum length of overlap in millimetres is given by 3,5 d × N.

The depth of the knee below the bottom of the beam is not to be less than the depth of the beam.

3. **Welded beam knees.**

(*a*) The length of overlap on beam or frame in millimetres is not to be less than $20{,}8\sqrt{\text{modulus}} - 51$ with a minimum of 165 millimetres.

Where the modulus does not exceed 590 cm.$^3$ the length of a flanged knee may be 85% of that obtained from this formula with a minimum of 140 millimetres.

The depth of the knee below the bottom of the beam is not to be less than the depth of the beam.

(*b*) The area of weld in square centimetres is not to be less than

$2{,}4\sqrt{\text{modulus}} - 19{,}5$ when modulus $< 345$

and $1{,}12\sqrt{\text{modulus}} + 4{,}5$ when modulus $\geq 345$

The area of weld is defined as the product of throat thickness and length of weld. The throat thickness is not to be less than that required by Notes 5 and 6, Table 52 G.

4. **Longitudinal Framing.**

(*a*) *Frame brackets.* Where the deck is framed longitudinally the brackets connecting the side frames to the deck clear of transverses are to be in accordance with the above requirements based on the modulus of the frame, but the horizontal arm of the bracket is to be extended to a longitudinal.

(*b*) *End brackets of deck longitudinals.* Where deck longitudinals are cut at transverse bulkheads, the minimum sectional area of the bracket at the end of the longitudinal, and also the area of weld connection, are to be equal to the sectional area of the longitudinal.

The depth of the bracket below the longitudinal is to be at least equal to the depth of the longitudinal.

5. **Knees used as frame straps.**

(*a*) The number of rivets in the lower frame is to be not less than $1 + \frac{\sqrt{\text{modulus}_{LF}}}{4}$ to the nearest whole number with a minimum of four. ($\text{Modulus}_{LF}$ is the modulus of the lower frame.)

(*b*) The number of rivets in the upper frame is not to be less than $\frac{\sqrt{\text{modulus}_{UF}}}{4}$ to the nearest whole number with a minimum of three for butted or overlapped frames. ($\text{Modulus}_{UF}$ is the modulus of the upper frame.)

(*c*) Where butts of frames are welded, the total number of rivets in the combined frame arm is not to be less than $1 + \frac{\sqrt{\text{modulus}_{LF}}}{4}$ to the nearest whole number with not less than two rivets in each of the upper and lower frames.

(*d*) In no case is the total of the rivets in the upper and lower frames to be less than $1 + \frac{\sqrt{\text{modulus}_B}}{4}$ where $\text{modulus}_B$ is the modulus of the beam.

(*e*) The riveting or welding of the arm to the beam, and the overlap on the beam, are to be as required by paragraphs (2) or (3) above. The modulus to be used is that of the beam or lower frame, whichever is greater.

(*f*) The welding of the knee to the upper or lower frame is to be in accordance with paragraph 3(*b*) using the modulus of the upper or lower frame as appropriate.

(*g*) The minimum length of overlap on the lower frame in millimetres is to be $3{,}5\ d \times N$ for riveted knees or $20{,}8\sqrt{\text{modulus}_{LF}} - 51$ for welded knees, with a minimum of 165 millimetres.

(*h*) For butted or lapped frames the overlap on the 'tween deck frame is not to be less than $3{,}5\ d \times N$ for riveted knees or $20{,}8\ \sqrt{\text{modulus}_{UF}} - 51$ for welded knees, with a minimum of 165 millimetres.

(*i*) Where the frames are butted the thickness of beam knee, if required to be flanged, is to be increased 2 millimetres or, where $\text{modulus}_{LF}$ or $\text{modulus}_B$ (whichever is greater) does not exceed 590 $cm.^3$ it is to be flanged.

# TABLE 29
(SEE CONTINUATION)

## DECK GIRDERS

| NUMERAL | DEPTH OF END BRACKETS BELOW DECK | DEPTH OF WEB PLATE BELOW DECK AND MINIMUM THICKNESS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Millimetres 250×8,0 | Millimetres 275×8,5 | Millimetres 300×8,5 | Millimetres 325×8,5 | Millimetres 350×8,5 | Millimetres 375×9,0 | Millimetres 400×9,0 | Millimetres 425×9,0 | Millimetres 450×9,0 |
| | | *REDUCTION IN FACE AREA (SQUARE CENTIMETRES) PER ONE MILLIMETRE INCREASE IN WEB THICKNESS* (see also NOTE 4) | | | | | | | | |
| | | *0,7* | *0,8* | *0,9* | *1,0* | *1,0* | *1,1* | *1,2* | *1,2* | *1,3* |
| | | FACE AREA | | | | | | | | |
| | Millimetres | Square cms. | Square cms. | Square cms. | Square cms. | Square cms. | Square cms. | Square cms. | Square cms. | Square cms. |
| 50 | 490 | 7,5 | | | | | | | | |
| 100 | 540 | 20,0 | 16,5 | 13,5 | | | | | | |
| 200 | 630 | 38,0 | 33,0 | 29,0 | 25,0 | 21,5 | | | | |
| 300 | 720 | 55,5 | 49,0 | 43,5 | 38,5 | 34,0 | 29,5 | 26,5 | 23,5 | 20,5 |
| 400 | 790 | 77,0 | 68,0 | 61,0 | 54,5 | 48,5 | 43,5 | 39,0 | 35,0 | 31,5 |
| 600 | 870 | | 106,0 | 96,0 | 86,5 | 77,5 | 70,0 | 64,5 | 59,0 | 54,0 |
| 800 | 940 | | | 131,0 | 119,5 | 108,5 | 98,5 | 90,5 | 83,5 | 77,0 |
| 1000 | 1000 | | | 165,0 | 151,5 | 138,0 | 126,5 | 117,0 | 107,5 | 100,0 |
| 1200 | 1060 | | | | 182,5 | 167,5 | 154,5 | 143,0 | 132,0 | 122,5 |
| 1400 | 1120 | | | | | | | 170,0 | 156,5 | 146,0 |
| 1600 | 1180 | | | | | | | | 179,5 | 168,5 |
| 1800 | 1240 | | | | | | | | | 191,0 |
| 2000 | | | | | | | | | | |
| 2200 | | | | | | | | | | |
| 2400 | | | | | | | | | | |
| 2600 | | | | | | | | | | |

*For notes see page 135*

# DECK GIRDERS

| DEPTH OF WEB PLATE BELOW DECK AND MINIMUM THICKNESS | | | | | | | | | DEPTH OF END BRACKETS BELOW DECK | NUMERAL |
|---|---|---|---|---|---|---|---|---|---|---|
| Millimetres 475 × 9,5 | Millimetres 500 × 9,5 | Millimetres 525 × 9,5 | Millimetres 550 × 9,5 | Millimetres 575 × 10,0 | Millimetres 600 × 10,0 | Millimetres 625 × 10,0 | Millimetres 650 × 10,0 | Millimetres 675 × 10,5 | | |
| *REDUCTION IN FACE AREA (SQUARE CENTIMETRES) PER ONE MILLIMETRE INCREASE IN WEB THICKNESS* (see also NOTE 4) | | | | | | | | | | |
| *1,4* | *1,5* | *1,5* | *1,6* | *1,6* | *1,7* | *1,8* | *1,9* | *2,0* | | |
| FACE AREA | | | | | | | | | | |
| Square cms. | Square cms. | Square cms. | Square cms. | Square cms. | Square cms. | Square cms. | Square cms. | Square cms. | Millimetres | |
| | | | | | | | | | 490 | 50 |
| | | | | | | | | | 540 | 100 |
| | | | | | | | | | 630 | 200 |
| | | | | | | | | | 720 | 300 |
| 28,0 | 24,5 | 22,0 | | | | | | | 790 | 400 |
| 49,0 | 44,5 | 41,0 | 37,5 | 33,5 | 30,5 | 27,5 | | | 870 | 600 |
| 71,0 | 65,0 | 60,5 | 56,0 | 51,5 | 47,5 | 44,0 | 40,5 | 36,5 | 940 | 800 |
| 92,5 | 85,5 | 79,5 | 74,5 | 69,0 | 64,0 | 60,0 | 56,0 | 51,5 | 1000 | 1000 |
| 113,5 | 105,5 | 99,0 | 93,0 | 86,5 | 81,5 | 75,5 | 71,5 | 66,5 | 1060 | 1200 |
| 136,0 | 127,0 | 118,5 | 111,5 | 104,0 | 97,5 | 92,5 | 87,0 | 81,5 | 1120 | 1400 |
| 157,5 | 147,5 | 138,5 | 130,0 | 122,0 | 115,0 | 108,5 | 103,0 | 96,5 | 1180 | 1600 |
| 179,5 | 168,0 | 158,0 | 148,5 | 140,0 | 132,0 | 125,0 | 118,5 | 111,5 | 1240 | 1800 |
| | 187,5 | 177,0 | 166,5 | 157,5 | 149,0 | 141,0 | 134,0 | 127,0 | | 2000 |
| | | | 184,0 | 174,5 | 166,0 | 157,0 | 149,5 | 142,0 | | 2200 |
| | | | | | | 172,5 | 165,0 | 157,0 | | 2400 |
| | | | | | | | | | | 2600 |

*For notes see page 135*

# TABLE 29

(SEE CONTINUATION)

## DECK GIRDERS

| NUMERAL | DEPTH OF END BRACKETS BELOW DECK | DEPTH OF WEB PLATE BELOW DECK AND MINIMUM THICKNESS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Millimetres 700 × 10,5 | Millimetres 725 × 10,5 | Millimetres 750 × 10,5 | Millimetres 775 × 11,0 | Millimetres 800 × 11,0 | Millimetres 825 × 11,0 | Millimetres 850 × 11,0 | Millimetres 875 × 11,5 | Millimetres 900 × 11,5 |
| | | *REDUCTION IN FACE AREA (SQUARE CENTIMETRES) PER ONE MILLIMETRE INCREASE IN WEB THICKNESS* (see also NOTE 4) | | | | | | | | |
| | | *2,0* | *2,1* | *2,2* | *2,2* | *2,3* | *2,3* | *2,4* | *2,5* | *2,5* |
| | | FACE AREA | | | | | | | | |
| 50 | Millimetres 490 | Square cms. | Square cms. | Square cms. | Square cms. | Square cms. | Square cms. | Square cms. | Square cms. | Square cms. |
| 100 | 540 | | | | | | | | | |
| 200 | 630 | | | | | | | | | |
| 300 | 720 | | | | | | | | | |
| 400 | 790 | | | | | | | | | |
| 600 | 870 | | | | | | | | | |
| 800 | 940 | 33,0 | 30,5 | | | | | | | |
| 1000 | 1000 | 48,0 | 46,5 | 41,0 | 37,5 | 34,0 | 31,0 | | | |
| 1200 | 1060 | 62,0 | 58,0 | 54,5 | 50,0 | 46,5 | 43,5 | 39,5 | 36,5 | 33,0 |
| 1400 | 1120 | 76,5 | 72,0 | 68,0 | 63,5 | 59,0 | 55,0 | 52,0 | 48,0 | 44,0 |
| 1600 | 1180 | 91,0 | 86,0 | 81,5 | 76,5 | 72,0 | 68,0 | 64,0 | 59,5 | 55,0 |
| 1800 | 1240 | 105,5 | 100,0 | 95,0 | 89,5 | 84,0 | 80,0 | 75,5 | 71,0 | 66,5 |
| 2000 | | 120,0 | 114,0 | 108,5 | 102,5 | 97,0 | 92,5 | 87,5 | 83,0 | 78,0 |
| 2200 | | 134,5 | 128,0 | 122,0 | 115,5 | 109,5 | 104,5 | 99,5 | 94,5 | 89,0 |
| 2400 | | 149,5 | 142,5 | 135,5 | 128,5 | 122,0 | 116,5 | 111,0 | 106,0 | 100,0 |
| 2600 | | 163,5 | 156,5 | 149,0 | 141,5 | 135,0 | 129,0 | 123,5 | 118,0 | 111,5 |

*For notes see page 135*

## NOTES.—TABLE 29

1. **Longitudinal girders.**

The numeral for use in the Table is given by :

$$l^2 \times b \times h$$

where l = the span of the girder, in metres, from pillar to pillar, or from pillar to bulkhead less half the distance between the toe of the end bracket and the bulkhead.

b = the mean width of deck, in metres, supported by the girder.

h is to be measured as follows :

(*a*) For decks on which cargo is carried h is the mean height in metres from top of beam to top of beam of the 'tween decks next above the girder.

(*b*) For decks under accommodation spaces h is 1,22 metres. (*See also* Note 1 (*e*).)

(*c*) For weather decks, except in the forward 0,12L, h is 1,22 metres if the draught does not exceed 0,7D and 1,52 metres if the draught is 0,85D or greater, with intermediate values in proportion, D being measured to the uppermost continuous deck. (*See also* Note 1 (*e*).)

(*d*) **Weather decks.** For the forward 0,075L, h is to be 1,83 metres, irrespective of draught. Between 0,075L and 0,12L from forward, h is to be 1,52 metres, irrespective of draught.

(*e*) For decks above the uppermost continuous deck h, as given in (*b*) and (*c*), may be successively reduced by 0,3 metre for each deck to a minimum of 0,46 metre.

(*f*) Where decks support a hanging cargo, such as chilled meat, in addition to deck loads, the value of h is to be increased by 0,76 metre for one tier, 1,52 metres for two tiers and 2,30 metres for three tiers.

2. **Strong hatch side coamings and end beams in 'tween decks.**

(*a*) SIDE COAMINGS.

The numeral for use in the Table is given by :

$$1{,}1 \times l^2 \times b \times h$$

where l = the length of the hatchway in metres.

b = the mean breadth in metres of deck, including hatchway, supported by the coaming.

h = the mean height in metres of 'tween decks as in note 1.

(*b*) HATCH END BEAMS.

For strong hatch end beams which are supported at the centre line and carry the hatch side coamings only, the numeral for use in the Table is given by :

$$0{,}75\ B \times l \times b \times h$$

where B = the span of the hatch end beam, in metres, measured from the centre line to the ship's side less half the distance between the toe of the bracket and the ship's side.

l, b and h are measured as in note 2 (*a*).

Where the hatch end beam supports the hatch side coaming and, in addition, an adjacent longitudinal girder in line, the numeral is given by :

$$0{,}75\ B\ (l_1 \times b_1 \times h + l_2 \times b_2 \times h)$$

where $l_1$, $b_1$ and h are measured as in note 2 (*a*) and $l_2$ and $b_2$ are measured as in note 1.

(*c*) The depth of strong hatch end beams derived from the Table is to be maintained for the full breadth of the ship.

(*d*) Strong hatch side coamings and end beams supporting deck longitudinals in association with transverses will be specially considered.

3. **Transverses supporting deck longitudinals.**

The numeral for use in the Table is given by :

$$l^2 \times b \times h$$

where l = the span, in metres, of the transverse measured from pillar to pillar or from pillar to ship's side less half the distance between the toe of the bracket and the ship's side.

b is the length of deck in metres supported by the transverses.

h is measured as in note 1.

In single deck ships the depth of the transverses is to be increased by 15 per cent.

4. The sectional area of girder flanges derived from the Table may take the form of rolled sections, or flanged girder plates, with rider plates where necessary, the depth of the girder being measured to the bottom of the web. Where the depth of beam or longitudinal notches exceeds 50 per cent of the depth of the girder or 300 mm., whichever is less, the face area is to be suitably increased. The width of the flange is not to exceed the depth of the girder.

5. For end connections and constructional details *see* D 1505 to D 1515.

For spacing of girders and transverses in the forward 0,075 L *see* D 1501.

6. **Timber Deck Cargoes.** Where timber load lines are to be assigned, h in the foregoing formulæ for weather decks is to be taken at 1,52 metres where the beam B does not exceed 15,25 metres, and 1,83 metres where the beam is 18,3 metres or over, with intermediate values in proportion. In single deck ships the depth of the transverses supporting deck longitudinals (note 3) is to be increased by 30 per cent.

# DECK RUNNERS

| NUMERAL | DOUBLE ANGLES | | SINGLE ANGLE OR BULB ANGLE |
|---|---|---|---|
| | Millimetres | | Millimetres |
| 5 | 75 × 65 × 7,0 | ANGLES | 100 × 75 × 7,5 |
| 10 | 90 × 75 × 8,0 | | 120 × 75 × 8,5 |
| 15 | 100 × 75 × 9,0 | | 130 × 75 × 11,5 |
| 20 | 100 × 75 × 11,0 | | 140 × 75 × 12,5 |
| 25 | 120 × 75 × 9,5 | | 150 × 75 × 12,5 |
| 30 | 130 × 75 × 9,5 | BULB ANGLES | 150 × 75 × 8,5 |
| 35 | 130 × 75 × 11,5 | | 150 × 75 × 10,5 |
| 40 | 150 × 75 × 10,0 | | 165 × 75 × 10,0 |
| 45 | 150 × 75 × 11,0 | | 180 × 75 × 9,0 |
| 50 | 150 × 75 × 12,0 | | 180 × 75 × 10,5 |

**NOTES.—TABLE 30**

1. The numeral is to be determined in accordance with Table 29, note 1.
2. The runners are to be fitted with the deep flange vertical.

# TABLE 31

(SEE CONTINUATION)

## PILLARS

| NUMERAL | LENGTH AND FORM OF PILLAR | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Metres 2,5 | | | | | | Metres 3,0 | | | | | | Metres 4,0 | | |
| | TUBULAR | DOUBLE CHANNELS AND FACE PLATES | | SOLID | | | TUBULAR | DOUBLE CHANNELS AND FACE PLATES | | SOLID | | | TUBULAR | DOUBLE CHANNELS AND FACE PLATES | |
| | Outside diameter | CHANNELS | FACE PLATES | Diameter | Rivets in ends | | Outside diameter | CHANNELS | FACE PLATES | Diameter | Rivets in ends | | Outside diameter | CHANNELS | FACE PLATES |
| | mm | mm | mm | mm | No | mm | mm | mm | mm | mm | No | mm | mm | mm | mm |
| 10 | 65× 8,0 | | | 60 | 2 | 22 | 75× 8,0 | | | 65 | 2 | 22 | 90× 8,5 | | |
| 15 | 80× 8,5 | | | 65 | 2 | 22 | 90× 8,5 | | | 70 | 2 | 22 | 105× 9,0 | | |
| 20 | 95× 8,5 | | | 71 | 2 | 22 | 100× 9,0 | | | 77 | 2 | 22 | 120× 9 | | |
| 30 | 115× 9 | | | 81 | 2 | 22 | 120× 9,5 | | | 87 | 2 | 22 | 140× 9,5 | | |
| 40 | 140× 9 | | | 88 | 3 | 22 | 140× 9,5 | | | 95 | 3 | 22 | 155×10 | | |
| 60 | 160×10 | | | 105 | 3 | 25 | 170×10 | | | 115 | 3 | 25 | 190×10 | | |
| 80 | 200×10 | | | 115 | 4 | 25 | 205×10,5 | | | 125 | 4 | 25 | 230×10 | 200× 85× 85×11 | |
| 100 | 215×11 | 200× 85× 85×11 | | 120 | 4 | 25 | 225×10,5 | 200× 85× 85×11,5 | | 130 | 5 | 25 | 240×11 | 220× 90× 90×11 | |
| 120 | 235×11,5 | 220× 90× 90×11 | | 130 | 5 | 25 | 245×11,5 | 220× 90× 90×11,5 | | 140 | 5 | 25 | 255×12 | 240× 95× 95×12 | |
| 140 | 255×12,5 | 240× 95× 95×11,5 | | 140 | 6 | 25 | 255×12,5 | 260× 95× 95×12 | | 150 | 6 | 25 | 275×12,5 | 260× 95× 95×14 | |
| 160 | 265×13,5 | 260× 95× 95×12,5 | | | | | 270×13,5 | 260× 95× 95×14,5 | | | | | 285×13,5 | 240× 95× 95×12 | 250×10 |
| 180 | 300×13,5 | 260× 95× 95×14 | | | | | 300×13,5 | 240× 95× 95×12 | 250×10 | | | | 300×14 | 240× 95× 95×12 | 270×11 |
| 200 | 325×13,5 | 240× 95× 95×12 | 260×10,5 | | | | 325×14 | 240× 95× 95×14 | 270×11 | | | | 330×14 | 260× 95× 95×12 | 290×12 |
| 250 | 375×14,5 | 240× 95× 95×12 | 300×13 | | | | 380×14,5 | 260× 95× 95×12 | 300×13,5 | | | | 385×14,5 | 280×100×100×13 | 320×14 |
| 300 | 425×15 | 260× 95× 95×12 | 320×15,5 | | | | 435×15 | 280×100×100×13 | 320×16 | | | | 435×15,5 | 300×100×100×13 | 340×16,5 |
| 350 | 460×15,5 | 280×100×100×13 | 340×17,5 | | | | 460×16 | 300×100×100×13 | 340×18 | | | | 470×16,5 | | |
| 400 | 470×16,5 | | | | | | 480×16,5 | | | | | | 510×17 | | |
| 450 | 500×17 | | | | | | 510×17 | | | | | | 560×17 | | |
| 500 | 555×17 | | | | | | 555×17,5 | | | | | | 590×18 | | |
| 550 | 595×18 | | | | | | 625×18 | | | | | | 645×18,5 | | |
| 600 | 645×18,5 | | | | | | 650×19 | | | | | | 660×19,5 | | |
| 650 | 655×19,5 | | | | | | 675×19,5 | | | | | | 695×20 | | |
| 700 | 680×20 | | | | | | 705×20 | | | | | | 730×20,5 | | |
| 750 | 720×20,5 | | | | | | 740×20,5 | | | | | | 780×20,5 | | |

*For notes see page 140*

| LENGTH AND FORM OF PILLAR | | | | | | | | | | | | | | NUMERAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Metres 4,0 | | | Metres 5,0 | | | | | | Metres 6,0 | | | | | |
| SOLID | | | TUBULAR | DOUBLE CHANNELS AND FACE PLATES | | SOLID | | | TUBULAR | DOUBLE CHANNELS AND FACE PLATES | | SOLID | | |
| Diameter | Rivets in ends | | Outside diameter | CHANNELS | FACE PLATES | Diameter | Rivets in ends | | Outside diameter | CHANNELS | FACE PLATES | Diameter | Rivets in ends | |
| mm | No. | mm | mm | mm | mm | mm | No. | mm | mm | mm | mm | mm | No. | mm | |
| 74 | 2 | 22 | 95× 9,0 | | | 81 | 2 | 22 | 105× 9,5 | | | 95 | 3 | 22 | 10 |
| 81 | 2 | 22 | 120× 9,0 | | | 92 | 2 | 22 | 125× 9,5 | | | 105 | 3 | 22 | 15 |
| 89 | 2 | 22 | 135× 9,5 | | | 100 | 3 | 22 | 150× 9,5 | | | 110 | 3 | 22 | 20 |
| 100 | 3 | 22 | 155×10 | | | 120 | 3 | 22 | 170×10 | | | 135 | 4 | 22 | 30 |
| 110 | 3 | 22 | 175×10 | | | 130 | 4 | 22 | 190×10 | 200× 85× 85×11 | | 150 | 4 | 25 | 40 |
| 135 | 4 | 25 | 215×10 | | | 155 | 5 | 25 | 225×10,5 | 220× 90× 90×11 | | | | | 60 |
| 145 | 5 | 25 | 230×11 | 200× 85× 85×11,5 | | 165 | 6 | 25 | 245×11 | 240× 95× 95×12 | | | | | 80 |
| 155 | 6 | 25 | 250×11,5 | 240× 95× 95×12 | | | | | 270×11,5 | 260× 95× 95×12 | | | | | 100 |
| 160 | 6 | 25 | 260×12,5 | 260× 95× 95×13 | | | | | 305×12,5 | 280×100×100×14 | | | | | 120 |
| 170 | 6 | 25 | 280×12,5 | 280×100×100×14 | | | | | 305×13 | 240× 95× 95×12 | 250×10 | | | | 140 |
| | | | 300×13,5 | 240× 95× 95×12 | 270×11,5 | | | | 320×13,5 | 240× 95× 95×12 | 290×12,5 | | | | 160 |
| | | | 320×14 | 260× 95× 95×12 | 290×12,5 | | | | 340×14 | 260× 95× 95×12 | 300×13,5 | | | | 180 |
| | | | 340×14 | 260× 95× 95×12 | 300×14 | | | | 360×14,5 | 260× 95× 95×12,5 | 300×15,5 | | | | 200 |
| | | | 400×14,5 | 300×100×100×13 | 340×15,5 | | | | 410×15,5 | 300×100×100×13 | 340×17 | | | | 250 |
| | | | 450×15 | | | | | | 455×16,5 | | | | | | 300 |
| | | | 490×16,5 | | | | | | 500×17 | | | | | | 350 |
| | | | 540×17 | | | | | | 565×17 | | | | | | 400 |
| | | | 565×18 | | | | | | 585×18 | | | | | | 450 |
| | | | 600×18,5 | | | | | | 630×18,5 | | | | | | 500 |
| | | | 655×18,5 | | | | | | 665×19,5 | | | | | | 550 |
| | | | 680×19,5 | | | | | | 690×20,5 | | | | | | 600 |
| | | | 705×20,5 | | | | | | 735×21 | | | | | | 650 |
| | | | 760×20,5 | | | | | | 790×21 | | | | | | 700 |
| | | | | | | | | | | | | | | | 750 |

*For notes see page 140*

# TABLE 31
(CONCLUDED)

## PILLARS

| NUMERAL | LENGTH AND FORM OF PILLAR | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Metres 7,0 | | | | | | Metres 8,0 | | | | | |
| | TUBULAR | DOUBLE CHANNELS AND FACE PLATES | | SOLID | | | TUBULAR | DOUBLE CHANNELS AND FACE PLATES | | SOLID | | |
| | Outside diameter | CHANNELS | FACE PLATES | Diameter | Rivets in ends | | Outside diameter | CHANNELS | FACE PLATES | Diameter | Rivets in ends | |
| | mm. | mm. | mm. | mm. | No | mm. | mm. | mm. | mm. | mm. | No. | mm. |
| 10 | | | | 105 | 3 | 22 | | | | 115 | 4 | 22 |
| 15 | | | | 115 | 3 | 22 | | | | 130 | 4 | 22 |
| 20 | 165× 9,5 | | | 125 | 3 | 22 | 185× 9,5 | | | 140 | 4 | 22 |
| 30 | 185×10 | 200× 85× 85×11,5 | | 150 | 4 | 25 | 205×10 | 220× 90× 90×11,5 | | | | |
| 40 | 205×10,5 | 200× 85× 85×12,5 | | | | | 215×11 | 240× 95× 95×12 | | | | |
| 60 | 230×11 | 220× 90× 90×13,5 | | | | | 245×11 | 240× 95× 95×14 | | | | |
| 80 | 255×11,5 | 240× 95× 95×13,5 | | | | | 260×12 | 260× 95× 95×14,5 | | | | |
| 100 | 270×12,5 | 260× 95× 95×15 | | | | | 275×13 | 240× 95× 95×12 | 250×10 | | | |
| 120 | 290×13 | 220× 90× 90×12 | 260×11 | | | | 310×13 | 240× 95× 95×12 | 270×12 | | | |
| 140 | 325×13 | 240× 95× 95×12 | 290×12,5 | | | | 345×13 | 260× 95× 95×12 | 300×13 | | | |
| 160 | 335×14 | 260× 95× 95×12 | 300×14 | | | | 355×14 | 260× 95× 95×12 | 310×15,5 | | | |
| 180 | 365×14 | 260× 95× 95×12 | 310×15,5 | | | | 380×14,5 | 280×100×100×13 | 320×17 | | | |
| 200 | 370×15 | 280×100×100×13 | 320×17,5 | | | | 400×15 | 300×100×100×14 | 330×18,5 | | | |
| 250 | 430×16 | | | | | | 450×16 | | | | | |
| 300 | 470×17 | | | | | | 490×17 | | | | | |
| 350 | 520×17,5 | | | | | | 525×18 | | | | | |
| 400 | 585×17,5 | | | | | | | | | | | |
| 450 | 585×18,5 | | | | | | | | | | | |
| 500 | 640×19,5 | | | | | | | | | | | |
| 550 | 710×19,5 | | | | | | | | | | | |
| 600 | | | | | | | | | | | | |
| 650 | | | | | | | | | | | | |
| 700 | | | | | | | | | | | | |
| 750 | | | | | | | | | | | | |

### NOTES.—TABLE 31

1. The numeral for use in the Table is to be the sum of the numerals representing the separate loads which may be transmitted to the pillar, namely :

(*a*) The numeral in respect of that proportion of the deck load, supported by a girder, hatch end beam or deck transverse, which is borne by the pillar.

(*b*) The numeral of the directly superimposed pillar, if any.

2. The numeral is to be determined by :

$$s \times b \times h$$

where s = the distance in metres between the centres of the two adjacent spans of girder supported by the pillar.

b = the mean width of deck, including hatchway if necessary, supported by the girders over the distance s.

h is to be measured as defined in Table 29, note 1.

3. Pillars equivalent to those shown in the Tables, of riveted or welded construction, will be accepted.

When hollow square pillars are fitted, the thickness is to be the same as that of the tubular pillar required and the side is to be 80 per cent of the diameter of the tubular pillar.

4. When solid pillars are fitted in pairs to take shifting boards, their diameter is to be 75 per cent of that required by the Table.

5. For end connections and constructional details *see* D 1516 to D 1524.

6. **Timber Deck Cargoes.** Where timber load lines are to be assigned, h is to be measured as defined in Table 29, note 6.

# BULKHEAD PLATING

Stiffeners spaced 760 mm. apart on watertight bulkheads and 610 mm. apart on collision, deep tank, peak tank and oil fuel bunker bulkheads

| DEPTH (*See* NOTE 1) | THICKNESS | DEPTH (*See* NOTE 1) | THICKNESS |
|---|---|---|---|
| Metres | Millimetres | Metres | Millimetres |
| 2,2 | 6,5 | 10,5 | 10 |
| 3,4 | 7 | 11,75 | 10,5 |
| 4,6 | 7,5 | 12,95 | 11 |
| 5,8 | 8 | 14,15 | 11,5 |
| 7,0 | 8,5 | 15,35 | 12 |
| 8,15 | 9 | 16,55 | 12,5 |
| 9,35 | 9,5 | 17,75 | 13 |

## NOTES.—TABLE 32

1. **Depth** is to be measured as follows :—

(*a*) **For watertight bulkheads** (D 16).—From the lower edge of the plate to the top of the bulkhead at the centre line.

(*b*) **For bulkheads of tanks** (D 19 and D 20).—From the lower edge of the plate to the top of the tank or to a point midway between the half-depth of the tank and the top of the overflow, whichever distance is greater.

2. **Correction for spacing of stiffeners.**—Where the spacing of stiffeners differs from that given in the Table the thickness of the plating is to be modified at the rate of 2 per cent for every 25 mm. of difference except that where the spacing on tank or oil bunker bulkheads exceeds 610 mm. the thickness is to be increased at the rate of 3 per cent per 25 mm. difference of spacing.

3. **Additions to thickness**, as corrected by note 2, are to be made as follows :—

(*a*) To the lowest strake of hold and tank bulkheads ... .. ... ... ... ... 1 mm.

(*b*) To the lowest strake of stokehold bulkheads in coal burning ships ... ... ... ... 2,5 mm.

(*c*) Plates in limbers and at the bottom of peak bulkheads ... ... ... ... ... ... 2,5 mm.

(*d*) In way of the stern tube, plating to be increased substantially or doubled.

4. The plating of deep tank, peak tank and oil fuel bunker bulkheads in ships exceeding 46 metres in length is not to be less than 7,5 mm. after correction.

Spaced 610 mm. apart on collision bulkheads

| LENGTH OF STIFFENER | HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER METRES | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 0,6 | 1,2 | 1,8 | 2,4 | 3,0 |
| Metres | Millimetres *Modulus—centimetres³* | | | | | |
| 2,4 | 100 × 65 × 7,5 *25,9* | 100 × 75 × 9,5 *33,1* | 100 × 75 × 10,5 *37,1* | 120 × 75 × 8,5 *42,1* | 130 × 75 × 9 *50,7* | 140 × 75 × 9 *57,5* |
| 2,7 | 100 × 75 × 10 *34,8* | 120 × 75 × 8,5 *42,7* | 130 × 75 × 8,5 *47,5* | 140 × 75 × 8,5 *57,1* | 150 × 75 × 9 *67,4* | 150 × 75 × 10 *72,2* |
| 3,0 | 130 × 75 × 8 *45,0* | 140 × 75 × 8,5 *55,1* | 150 × 75 × 8,5 *64,1* | 150 × 75 × 9,5 *71,9* | 140 × 65 × 8 *87,5* | 150 × 75 × 8,5 *107* |
| 3,3 | 140 × 75 × 9 *57,5* | 150 × 75 × 9 *68,0* | 140 × 65 × 8 *86,9* | 140 × 65 × 9 *94,5* | 150 × 75 × 8,5 *109* | 165 × 75 × 8,5 *131* |
| 3,6 | 150 × 75 × 9,5 *71,8* | 140 × 65 × 8,5 *90,1* | 150 × 75 × 8,5 *109* | 150 × 75 × 9,5 *116* | 165 × 75 × 8,5 *135* | 180 × 75 × 8 *158* |
| 3,9 | 140 × 65 × 8,5 *92,8* | 150 × 75 × 9 *112* | 165 × 75 × 8,5 *131* | 165 × 75 × 9 *138* | 180 × 75 × 8,5 *163* | 180 × 75 × 10,5 *189* |
| 4,2 | 150 × 75 × 9 *112* | 165 × 75 × 8,5 *132* | 180 × 75 × 8 *159* | 180 × 75 × 9 *167* | 180 × 75 × 11 *192* | 200 × 75 × 9,5 *222* |
| 4,5 | 165 × 75 × 8,5 *132* | 180 × 75 × 8 *159* | 180 × 75 × 10,5 *189* | *199* | 200 × 75 × 10 *227* | 200 × 75 × 12 *257* |
| 4,8 | 180 × 75 × 8 *159* | 180 × 75 × 10,5 *188* | 200 × 75 × 9,5 *221* | 200 × 75 × 10,5 *232* | 200 × 90 × 12,5 *264* | *299* |
| 5,1 | 180 × 75 × 10,5 *189* | 200 × 75 × 9,5 *221* | 200 × 75 × 12 *257* | 200 × 90 × 13 *269* | *308* | 230 × 90 × 12 *344* |
| 5,4 | 200 × 75 × 9,5 *221* | 200 × 75 × 12 *257* | *300* | *312* | 230 × 90 × 12,5 *347* | *387* |
| 5,7 | 200 × 75 × 12 *257* | *299* | 230 × 90 × 11 *325* | 230 × 90 × 12,5 *352* | *390* | 250 × 90 × 12,5 *439* |
| 6,0 | *300* | 230 × 90 × 12 *344* | *379* | 250 × 90 × 12,5 *431* | 250 × 90 × 13,5 *454* | *489* |
| 6,3 | 230 × 90 × 12 *344* | *387* | 250 × 90 × 12,5 *432* | *490* | *503* | 280 × 90 × 12,5 *552* |
| 6,6 | *387* | 250 × 90 × 12,5 *432* | *484* | 280 × 90 × 12 *538* | 280 × 90 × 13,5 *581* | *615* |
| 6,9 | 250 × 90 × 12,5 *432* | *484* | 280 × 90 × 12 *538* | 280 × 90 × 14 *595* | *635* | 300 × 90 × 13 *665* |
| 7,2 | *485* | 280 × 90 × 12 *539* | 280 × 90 × 14 *595* | *656* | 300 × 90 × 13,5 *682* | 300 × 90 × 15 *726* |
| 7,5 | 280 × 90 × 12 *539* | 280 × 90 × 14 *595* | *656* | 300 × 90 × 14,5 *713* | 300 × 90 × 15,5 *743* | 300 × 100 × 100 × 14 *808* |
| 7,8 | 280 × 90 × 14 *595* | *656* | 300 × 90 × 14,5 *713* | *769* | 300 × 100 × 100 × 14,5 *820* | 320 × 100 × 100 × 13,5 *879* |
| 8,1 | *656* | 300 × 90 × 14 *695* | 300 × 90 × 16 *754* | 300 × 100 × 100 × 16 *847* | 320 × 100 × 100 × 14,5 *913* | |

ANGLES — BULB ANGLES

*For notes see page 149*

and 760 mm. apart on other watertight bulkheads

| HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER METRES | | | | | | LENGTH OF STIFFENER |
|---|---|---|---|---|---|---|
| 3,6 | 4,2 | 4,8 | 5,4 | 6,0 | | |
| Millimetres *Modulus—centimetres³* | | | | | | Metres |
| 150 × 75 × 8,5<br>*63,5* | 150 × 75 × 9<br>*66,8* | 150 × 75 × 10,5<br>*75,9* | 140 × 65 × 8<br>*87,1* | 140 × 65 × 8,5<br>*92,0* | BULB ANGLES | 2,4 |
| 140 × 65 × 8<br>*86,0* | 140 × 65 × 9<br>*93,1* | 150 × 75 × 8,5<br>*107* | 150 × 75 × 9<br>*112* | 165 × 75 × 8<br>*129* | | 2,7 |
| 150 × 75 × 9<br>*112* | 150 × 75 × 9,5<br>*116* | 165 × 75 × 8,5<br>*131* | 165 × 75 × 9<br>*138* | 180 × 75 × 8<br>*158* | | 3,0 |
| 165 × 75 × 9<br>*137* | 165 × 75 × 10,5<br>*154* | 180 × 75 × 8,5<br>*164* | 180 × 75 × 10,5<br>*185* | 180 × 75 × 11<br>*194* | | 3,3 |
| 180 × 75 × 8,5<br>*165* | 180 × 75 × 10,5<br>*188* | 180 × 75 × 11<br>*194* | 200 × 75 × 9,5<br>*221* | 200 × 75 × 10<br>*230* | | 3,6 |
| 180 × 75 × 11<br>*195* | 200 × 75 × 9,5<br>*221* | 200 × 75 × 10,5<br>*233* | 200 × 90 × 13<br>*268* | *294* | | 3,9 |
| 200 × 75 × 10,5<br>*232* | 200 × 75 × 12<br>*257* | *285* | *304* | 230 × 90 × 11,5<br>*337* | | 4,2 |
| 200 × 90 × 13<br>*270* | *299* | 230 × 90 × 11<br>*321* | 230 × 90 × 12<br>*345* | *383* | | 4,5 |
| *313* | 230 × 90 × 12<br>*344* | *379* | 250 × 90 × 12<br>*420* | 250 × 90 × 13<br>*446* | | 4,8 |
| 230 × 90 × 12,5<br>*353* | *389* | 250 × 90 × 12,5<br>*438* | *485* | *537* | | 5,1 |
| 250 × 90 × 12<br>*422* | *473* | *498* | 280 × 90 × 12<br>*547* | 280 × 90 × 14,5<br>*598* | | 5,4 |
| *485* | 280 × 90 × 12<br>*547* | 280 × 90 × 14<br>*585* | 280 × 90 × 14,5<br>*608* | *656* | | 5,7 |
| 280 × 90 × 12<br>*547* | 280 × 90 × 14,5<br>*599* | *634* | 300 × 90 × 13<br>*661* | 300 × 90 × 14<br>*702* | | 6,0 |
| 280 × 90 × 14,5<br>*604* | *656* | 300 × 90 × 13,5<br>*674* | 300 × 90 × 15<br>*725* | *751* | CHANNELS | 6,3 |
| *659* | 300 × 90 × 14,5<br>*712* | 300 × 90 × 15,5<br>*732* | 300 × 100 × 100 × 14<br>*805* | 300 × 100 × 100 × 15<br>*827* | | 6,6 |
| 300 × 90 × 15<br>*717* | 300 × 90 × 16<br>*754* | 300 × 100 × 100 × 14<br>*809* | 320 × 100 × 100 × 14<br>*895* | 320 × 100 × 100 × 15<br>*922* | | 6,9 |
| 300 × 100 × 100 × 13<br>*772* | 300 × 100 × 100 × 14,5<br>*821* | 320 × 100 × 100 × 14<br>*897* | 350 × 100 × 100 × 14,5<br>*990* | 350 × 100 × 100 × 15,5<br>*1019* | | 7,2 |
| 300 × 100 × 100 × 15,5<br>*845* | | | | | | 7,5 |
| | | | | | | 7,8 |
| | | | | | | 8,1 |

*For notes see page 149*

# TABLE 33
(CONCLUDED)

## BULKHEAD STIFFENERS

**Spaced 610 mm. apart on collision bulkheads**

| LENGTH OF STIFFENER | | HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER METRES | | | | |
|---|---|---|---|---|---|---|
| | | 6,6 | 7,2 | 7,8 | 8,4 | 9,0 |
| Metres | | Millimetres *Modulus—centimetres*³ | | | | |
| 2,4 | BULB ANGLES | 150×75× 8,5<br>*107* | 150×75× 9<br>*112* | 150×75× 9,5<br>*117* | 165×75× 8<br>*129* | 165×75× 8,5<br>*134* |
| 2,7 | | 165×75× 9<br>*138* | 165×75× 9,5<br>*142* | 180×75× 8<br>*157* | 180×75× 9<br>*167* | 180×75×10<br>*183* |
| 3,0 | | 180×75× 9<br>*168* | 180×75×10,5<br>*185* | 180×75×11<br>*195* | *201* | 200×75× 9,5<br>*220* |
| 3,3 | | 200×75× 9<br>*216* | 200×75×10<br>*229* | 200×75×10,5<br>*234* | 200×75×11,5<br>*252* | 200×90×12,5<br>*265* |
| 3,6 | | 200×75×12<br>*256* | 200×90×13<br>*266* | *287* | *302* | *317* |
| 3,9 | | *309* | *315* | 230×90×12<br>*341* | 230×90×12,5<br>*352* | *380* |
| 4,2 | | 230×90×12,5<br>*349* | *379* | *394* | 250×90×12<br>*423* | 250×90×13<br>*447* |
| 4,5 | | 250×90×12<br>*421* | 250×90×13<br>*443* | *475* | *497* | *529* |
| 4,8 | | *485* | *501* | 280×90×12<br>*546* | 280×90×14<br>*585* | 280×90×14,5<br>*605* |
| 5,1 | | 280×90×12,5<br>*557* | 280×90×14<br>*586* | 280×90×14,5<br>*608* | *654* | 300×90×13<br>*671* |
| 5,4 | | *612* | *655* | 300×90×13,5<br>*679* | 300×90×14,5<br>*704* | 300×90×15,5<br>*731* |
| 5,7 | | 300×90×13<br>*670* | 300×90×14,5<br>*703* | 300×90×15,5<br>*735* | *760* | 300×100×100×14<br>*809* |
| 6,0 | | 300×90×15,5<br>*731* | *758* | 300×100×100×14<br>*808* | 300×100×100×15,5<br>*843* | 320×100×100×14<br>*898* |
| 6,3 | CHANNELS | 300×100×100×14<br>*808* | 300×100×100×15,5<br>*843* | 320×100×100×14<br>*902* | 320×100×100×15,5<br>*939* | 350×100×100×14,5<br>*992* |
| 6,6 | | 320×100×100×14<br>*896* | 320×100×100×15,5<br>*938* | 350×100×100×15<br>*1005* | 350×100×100×16<br>*1039* | |
| 6,9 | | 350×100×100×14,5<br>*992* | 350×100×100×16<br>*1035* | | | |
| 7,2 | | | | | | |
| 7,5 | | | | | | |
| 7,8 | | | | | | |
| 8,1 | | | | | | |

*For notes see page 149*

# TABLE 33
(CONCLUDED)

and 760 mm. apart on other watertight bulkheads

| HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER METRES | | | | | | LENGTH OF STIFFENER |
|---|---|---|---|---|---|---|
| 9,6 | 10,2 | 10,8 | 11,4 | 12,0 | | |
| Millimetres *Modulus—centimetres³* | | | | | | Metres |
| 165 × 75 × 9<br>*137* | 180 × 75 × 8<br>*155* | 180 × 75 × 8,5<br>*162* | 180 × 75 × 8,5<br>*165* | 180 × 75 × 10,5<br>*184* | BULB ANGLES | 2,4 |
| 180 × 75 × 10,5<br>*188* | 180 × 75 × 11<br>*194* | 200 × 75 × 9<br>*212* | 200 × 75 × 9,5<br>*222* | 200 × 75 × 10<br>*229* | | 2,7 |
| 200 × 75 × 10<br>*230* | 200 × 75 × 11,5<br>*248* | 200 × 90 × 12,5<br>*260* | 200 × 90 × 13<br>*269* | <br>*293* | | 3,0 |
| <br>*293* | <br>*309* | <br>*315* | 230 × 90 × 11<br>*320* | 230 × 90 × 12<br>*342* | | 3,3 |
| 230 × 90 × 12<br>*343* | 230 × 90 × 12,5<br>*354* | <br>*379* | <br>*397* | 250 × 90 × 12<br>*422* | | 3,6 |
| <br>*394* | 250 × 90 × 12<br>*422* | 250 × 90 × 13<br>*447* | <br>*478* | <br>*498* | | 3,9 |
| <br>*476* | <br>*522* | 280 × 90 × 12<br>*546* | 280 × 90 × 13<br>*560* | 280 × 90 × 14<br>*587* | | 4,2 |
| 280 × 90 × 12,5<br>*557* | 280 × 90 × 14<br>*594* | <br>*611* | <br>*622* | <br>*654* | | 4,5 |
| <br>*620* | <br>*656* | 300 × 90 × 13<br>*672* | 300 × 90 × 13,5<br>*685* | 300 × 90 × 15<br>*723* | | 4,8 |
| 300 × 90 × 13,5<br>*684* | 300 × 90 × 15<br>*724* | 300 × 90 × 16<br>*746* | <br>*758* | 300 × 100 × 100 × 14<br>*804* | CHANNELS | 5,1 |
| 300 × 90 × 16<br>*748* | 300 × 100 × 100 × 14<br>*804* | 300 × 100 × 100 × 15<br>*832* | 300 × 100 × 100 × 16<br>*848* | 320 × 100 × 100 × 14<br>*896* | | 5,4 |
| 300 × 100 × 100 × 15<br>*830* | 320 × 100 × 100 × 14<br>*893* | 320 × 100 × 100 × 15<br>*927* | 350 × 100 × 100 × 14<br>*973* | 350 × 100 × 100 × 15,5<br>*1014* | | 5,7 |
| 320 × 100 × 100 × 15<br>*925* | 350 × 100 × 100 × 14,5<br>*988* | 350 × 100 × 100 × 15,5<br>*1023* | | | | 6,0 |
| 350 × 100 × 100 × 15,5<br>*1031* | | | | | | 6,3 |
| | | | | | | 6,6 |
| | | | | | | 6,9 |
| | | | | | | 7,2 |
| | | | | | | 7,5 |
| | | | | | | 7,8 |
| | | | | | | 8,1 |

*For notes see page 149*

Spaced 610 mm. apart on collision bulkhead

| LENGTH OF STIFFENER | | HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER — METRES | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 0,6 | 1,2 | 1,8 | 2,4 | 3,0 | 3,6 |
| Metres | | MILLIMETRES — *Modulus—centimetres*[3] | | | | | | |
| 2,4 | ANGLES | * 100×65×10,5 *36,1* | 120×75× 9,5 *47,2* | 140×75× 9 *57,9* | 150×75× 9,5 *70,9* | 140×65× 8,5 *91,3* | 140×65× 9 *95,8* | 150×75× 8,5 *110* |
| 2,7 | ANGLES | * 130×75× 9,5 *54,7* | 140×75× 9,5 *61,7* | 140×65× 8,5 *89,5* | 140×65× 9 *95,4* | 150×75× 8,5 *110* | 150×75× 9,5 *119* | 165×75× 8,5 *133* |
| 3,0 | ANGLES | * 150×75× 9,5 *71,9* | 140×65× 8,5 *91,9* | 150×75× 8,5 *110* | 165×75× 8,5 *130* | 165×75× 9 *138* | 180×75× 8 *157* | 180×75× 9 *167* |
| 3,3 | BULB ANGLES | 140×65× 9 *94,8* | 150×75× 9 *115* | 165×75× 8,5 *133* | 180×75× 8,5 *160* | 180×75× 9 *169* | 180×75×11 *193* | 200×75× 9,5 *219* |
| 3,6 | BULB ANGLES | 150×75× 9,5 *119* | 165×75× 9,5 *142* | 180×75× 8,5 *164* | 180×75×11 *191* | *207* | 200×75×10,5 *232* | 200×90×12,5 *264* |
| 3,9 | BULB ANGLES | 165×75× 8,5 *134* | 180×75× 9 *167* | *199* | 200×75×10 *229* | 200×75×12 *255* | *296* | *314* |
| 4,2 | BULB ANGLES | 180×75× 9 *168* | *201* | 200×75×12 *253* | *273* | *308* | 230×90×12,5 *346* | 230×90×13 *361* |
| 4,5 | BULB ANGLES | *202* | 200×75×11 *242* | *301* | *319* | *352* | *392* | 250×90×12,5 *428* |
| 4,8 | BULB ANGLES | 200×75×12 *253* | *298* | 230×90×12,5 *346* | *382* | 250×90×11,5 *407* | 250×90×13,5 *456* | *496* |
| 5,1 | BULB ANGLES | *307* | 230×90×12,5 *346* | *392* | 250×90×13 *443* | *482* | *513* | 280×90×13 *568* |
| 5,4 | BULB ANGLES | 230×90×12,5 *349* | 250×90×11 *400* | 250×90×13,5 *456* | *499* | 280×90×13 *560* | 280×90×14,5 *596* | *652* |
| 5,7 | BULB ANGLES | *392* | 250×90×13,5 *450* | *508* | 280×90×13,5 *576* | *621* | 300×90×13 *663* | *728* |
| 6,0 | BULB ANGLES | *474* | *508* | 280×90×14 *587* | *656* | 300×90×13,5 *673* | *729* | 300×100×100×14,5 *812* |
| 6,3 | BULB ANGLES | *521* | 280×90×14 *583* | 300×90×13 *660* | 300×90×14,5 *706* | *733* | 300×100×100×14,5 *811* | 320×100×100×14 *902* |
| 6,6 | BULB ANGLES | 280×90×14 *588* | 300×90×13 *660* | 300×90×14,5 *707* | *758* | 300×100×100×14,5 *814* | 320×100×100×14,5 *903* | 350×100×100×14,5 *996* |
| 6,9 | BULB ANGLES | 300×90×13 *660* | 300×90×15 *716* | *767* | 300×100×100×15,5 *842* | 320×100×100×14,5 *904* | 350×100×100×14,5 *995* | |
| 7,2 | BULB ANGLES | 300×90×15 *717* | 300×100×100×13,5 *781* | 300×100×100×16 *854* | 320×100×100×15,5 *937* | 350×100×100×15 *1010* | | |
| 7,5 | CHANNELS | *773* | 320×100×100×13 *868* | 320×100×100×16 *953* | 350×100×100×16 *1035* | | | |
| 7,8 | CHANNELS | 300×100×100×16 *853* | 350×100×100×14 *971* | 350×100×100×16,5 *1060* | | | | |
| 8,1 | CHANNELS | 320×100×100×16 *952* | 380×100×100×13 *1079* | | | | | |

The ends of upper 'tween deck stiffeners marked * may be riveted to the boundary angle only without lug attachment

*For notes see page 149*

TABLE 34

(SEE CONTINUATION)

and 760 mm. apart on other watertight bulkheads

| HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER — METRES | | | | | | | | LENGTH OF STIFFENER |
|---|---|---|---|---|---|---|---|---|
| 4,2 | 4,8 | 5,4 | 6,0 | 6,6 | 7,2 | 7,8 | | |
| MILLIMETRES *Modulus—centimetres³* | | | | | | | | Metres |
| 150×75× 9,5<br>*119* | 165×75× 8,5<br>*130* | 165×75× 9<br>*137* | 180×75× 8<br>*158* | 180×75× 8,5<br>*164* | 180×75× 9<br>*169* | 180×75×10,5<br>*185* | BULB ANGLES | 2,4 |
| 180×75× 8<br>*157* | 180×75× 9<br>*168* | 180×75× 9,5<br>*176* | 180×75×11<br>*193* | 200×75× 9,5<br>*218* | 200×75×10<br>*228* | 200×75×12<br>*252* | | 2,7 |
| 180×75×11<br>*190* | *203* | 200×75×10<br>*225* | 200×75×12<br>*253* | 200×90×13<br>*269* | *296* | *311* | | 3,0 |
| 200×75×10,5<br>*233* | 200×75×12<br>*255* | *273* | *307* | 230×90×11<br>*320* | 230×90×12,5<br>*346* | *378* | | 3,3 |
| *296* | *310* | 230×90×12<br>*340* | 230×90×13<br>*359* | *387* | 250×90×11,5<br>*411* | 250×90×12,5<br>*434* | | 3,6 |
| 230×90×12,5<br>*346* | 230×90×13<br>*360* | 250×90×11<br>*399* | 250×90×12,5<br>*437* | *478* | *496* | 280×90×12<br>*538* | | 3,9 |
| 250×90×11<br>*399* | 250×90×12,5<br>*436* | *480* | *506* | 280×90×13<br>*559* | 280×90×14<br>*592* | *624* | | 4,2 |
| *479* | *506* | 280×90×13<br>*560* | 280×90×14<br>*592* | *649* | 300×90×13,5<br>*671* | 300×90×14<br>*697* | | 4,5 |
| *517* | 280×90×14<br>*585* | *627* | 300×90×13<br>*661* | *713* | *737* | 300×100×100×14<br>*801* | CHANNELS | 4,8 |
| 280×90×14,5<br>*604* | 300×90×13<br>*659* | 300×90×14,5<br>*706* | *733* | 300×100×100×14<br>*805* | 300×100×100×15<br>*830* | 320×100×100×14<br>*900* | | 5,1 |
| 300×90×13,5<br>*684* | *730* | 300×100×100×14<br>*806* | 300×100×100×15<br>*829* | 320×100×100×14<br>*901* | 350×100×100×13<br>*940* | 350×100×100×15<br>*1009* | | 5,4 |
| *756* | 300×100×100×14,5<br>*814* | 320×100×100×14<br>*901* | 320×100×100×15,5<br>*938* | 350×100×100×15<br>*998* | | | | 5,7 |
| 300×100×100×16<br>*847* | 320×100×100×14,5<br>*905* | 350×100×100×14,5<br>*995* | 350×100×100×16,5<br>*1059* | | | | | 6,0 |
| 350×100×100×13<br>*942* | 350×100×100×15,5<br>*1022* | | | | | | | 6,3 |
| | | | | | | | | 6,6 |
| | | | | | | | | 6,9 |
| | | | | | | | | 7,2 |
| | | | | | | | | 7,5 |
| | | | | | | | | 7,8 |
| | | | | | | | | 8,1 |

*For notes see page 149*

# TABLE 34
(CONCLUDED)

## BULKHEAD STIFFENERS—LUGGED

Spaced 610 mm. apart on collision bulkheads and 760 mm. apart on other watertight bulkheads

| LENGTH OF STIFFENER | | HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER METRES | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 8,4 | 9,0 | 9,6 | 10,2 | 10,8 | 11,4 | 12,0 |
| Metres | | MILLIMETRES *Modulus—centimetres³* | | | | | | |
| 2,4 | BULB ANGLES | *198* | 200×75×9,5 *219* | 200×75×10 *228* | 200×75×10,5 *235* | 200×90×12,5 *260* | 200×90×13 *270* | *273* |
| 2,7 | BULB ANGLES | 200×90×13 *267* | *275* | *296* | *309* | 230×90×11 *320* | 230×90×12 *341* | 230×90×12,5 *351* |
| 3,0 | BULB ANGLES | 230×90×11 *321* | 230×90×12 *341* | 230×90×13 *354* | *380* | *393* | 250×90×12 *423* | 250×90×13 *445* |
| 3,3 | BULB ANGLES | *392* | 250×90×12 *424* | 250×90×13 *444* | *477* | *495* | *507* | 280×90×12 *541* |
| 3,6 | BULB ANGLES | *476* | *505* | 280×90×12 *543* | 280×90×13 *567* | 280×90×14 *592* | *612* | *648* |
| 3,9 | BULB ANGLES | 280×90×13 *565* | 280×90×14 *592* | *624* | *655* | 300×90×13,5 *672* | 300×90×14 *687* | *726* |
| 4,2 | BULB ANGLES | *655* | 300×90×13,5 *671* | *706* | *735* | *749* | 300×100×100×14 *798* | 320×100×100×13,5 *875* |
| 4,5 | CHANNELS | *731* | *756* | 300×100×100×14 *807* | 300×100×100×15 *832* | 320×100×100×13,5 *883* | 320×100×100×15 *924* | 350×100×100×14,5 *989* |
| 4,8 | CHANNELS | 300×100×100×15 *830* | 320×100×100×13,5 *886* | 320×100×100×15 *924* | 350×100×100×14 *977* | 350×100×100×15,5 *1019* | 350×100×100×16 *1043* | |
| 5,1 | CHANNELS | 350×100×100×13 *940* | 350×100×100×14,5 *996* | 350×100×100×16 *1038* | | | | |
| 5,4 | CHANNELS | 350×100×100×16,5 *1062* | | | | | | |
| 5,7 | CHANNELS | | | | | | | |
| 6,0 | CHANNELS | | | | | | | |
| 6,3 | CHANNELS | | | | | | | |
| 6,6 | CHANNELS | | | | | | | |
| 6,9 | CHANNELS | | | | | | | |
| 7,2 | CHANNELS | | | | | | | |
| 7,5 | CHANNELS | | | | | | | |
| 7,8 | CHANNELS | | | | | | | |
| 8,1 | CHANNELS | | | | | | | |

*For notes see page 149*

## TABLE 35

## BULKHEAD STIFFENERS in TUGS

**Spaced 610 mm. apart on collision bulkheads and 760 mm. apart on other watertight bulkheads**

| LENGTH OF STIFFENER | STIFFENERS BRACKETED AT ENDS | STIFFENERS WITHOUT BRACKETS OR LUGS AT ENDS |
|---|---|---|
| **2,1** | | 80×65× 8,5<br>*20,7* |
| **2,4** | 75×65× 6,5<br>*14,5* | 100×75× 7,5<br>*26,4* |
| **2,7** | 75×65× 7,5<br>*16,0* | 100×75× 8,5<br>*30,4* |
| **3,0** | 80×65× 9<br>*21,8* | 100×75×10,5<br>*37,3* |
| **3,3** | 100×75× 8<br>*28,3* | 120×75× 9<br>*45,2* |
| **3,6** | 100×75×10<br>*34,7* | 130×75× 9,5<br>*55,1* |
| **3,9** | 120×75× 8,5<br>*42,7* | 150×75× 9<br>*67,7* |
| **4,2** | 130×75× 9,5<br>*54,2* | 150×75×10,5<br>*79,0* |
| **4,5** | 150×75× 9<br>*66,8* | 150×75×12,5<br>*91,2* |
| **4,8** | 150×75×10,5<br>*79* | |

## TABLE 36

## END ATTACHMENTS for STIFFENERS

| TYPE AND DEPTH OF STIFFENER | | BRACKET ATTACHMENTS | | | | LUG ATTACHMENTS | |
|---|---|---|---|---|---|---|---|
| | | Thickness of bracket | Width of flange | Number and size of rivets in each arm of bracket | Area of weld | Number and size of rivets in lug | Area of weld |
| | | mm. | mm. | | sq. cm. | | sq. cm. |
| Angles ... ... ... | | 8,5 | — | 3 of 19 mm. dia. | 9,7 | 2 of 19 mm. dia. | 6,5 |
| Bulb Angles 150 mm. and under ... ... | | 9 | — | 3 „ 19 „ „ | 9,7 | 2 „ 19 „ „ | 6,5 |
| Bulb Angles 180 mm. | | 10 | — | 4 „ 19 „ „ | 12,9 | 3 „ 19 „ „ | 9,7 |
| „ „ 200 „ | | 10,5 | — | 5 „ 19 „ „ | 16,1 | 3 „ 19 „ „ | 9,7 |
| „ „ 230 „ | FLANGED | 8,5 | 60 | 6 „ 19 „ „ | 19,3 | 4 „ 19 „ „ | 12,9 |
| „ „ 250 „ | | 9 | 65 | 7 „ 19 „ „ | 22,6 | 4 „ 19 „ „ | 12,9 |
| „ „ 280 „ | | 9,5 | 70 | 7 „ 22 „ „ | 30,6 | 4 „ 22 „ „ | 17,7 |
| „ „ 300 „ | | 10 | 75 | 8 „ 22 „ „ | 35,4 | 5 „ 22 „ „ | 22,6 |
| Channels 300× 90× 90 mm. | | 10 | 75 | 9 „ 22 „ „ | 40,3 | 6 „ 22 „ „ | 25,8 |
| Channels 300×100×100 mm. | | 10 | 75 | 10 „ 22 „ „ | 45,1 | 7 „ 22 „ „ | 30,6 |
| Channels 380×100×100 mm. | | 11 | 90 | 13 „ 22 „ „ | 58,0 | 8 „ 22 „ „ | 35,4 |

### NOTES.—TABLES 33, 34, 35 & 36

1. **Length of stiffeners** is to be measured over the full distance between the top and bottom boundaries of the bulkhead.

2. **Correction for spacing.**—If the spacing of the stiffeners differs from the Table spacing the modulus is to be modified in direct proportion.

3. **Welded construction.**—When the bulkhead plating, boundaries, stiffeners and end brackets are welded, the modulus of the stiffeners may, in general, be reduced by 15 per cent, but due consideration is to be given to stiffness and to the rigidity of the structure to which the end brackets are attached.

4. **Area of weld** is the product of the throat thickness and the length of the weld. The throat thickness is not to be less than that required by Notes 5 and 6, Table 52 G.

5. Particulars of sections and moduli are given in Table 56.

# TABLE 37

## TUNNEL PLATING

**Stiffeners spaced 915 mm. apart**

| DEPTH (*See* NOTE 1) | THICKNESS | | DEPTH (*See* NOTE 1) | THICKNESS | |
|---|---|---|---|---|---|
| | FLAT SIDE PLATING | CURVED TOP PLATING | | FLAT SIDE PLATING | CURVED TOP PLATING |
| Metres | Millimetres | Millimetres | Metres | Millimetres | Millimetres |
| **2,5** | 7,5 | 6,5 | **11** | 11,5 | 10 |
| **3** | 7,5 | 7 | **12** | 12 | 10,5 |
| **4** | 8 | 7 | **13** | 12,5 | 11 |
| **5** | 8,5 | 7,5 | **14** | 12,5 | 11,5 |
| **6** | 9 | 8 | **15** | 13 | 12 |
| **7** | 9,5 | 8,5 | **16** | 14 | 12,5 |
| **8** | 10 | 9 | **17** | 14 | 12,5 |
| **9** | 10,5 | 9,5 | **18** | 14,5 | 13 |
| **10** | 11 | 9,5 | | | |

### NOTES.—TABLE 37

1. **Depth** is to be measured at mid-length of the tunnel from the bulkhead deck at the centre line to the lower edge of the plate.

2. **Correction for spacing of stiffeners.** When the spacing differs from 915 mm. the thickness is to be modified at the rate of 2 per cent for every 25 mm. of difference.

3. For additions under hatchways *see* D 1702 to D 1703.

For tunnels in deep tanks *see* D 1910 and D 2015.

# TUNNEL STIFFENERS

**Spaced 915 mm. apart**

| DEPTH (*See* NOTE 1) | LENGTH FROM BASE OF TUNNEL TO TOP OF FLAT SIDE | | | | | |
|---|---|---|---|---|---|---|
| | 0,9 | 1,2 | 1,5 | 1,8 | 2,1 | 2,4 |
| Metres | Millimetres<br>*Modulus—centimetres³* | | | | | |
| 3,6 | 75×65× 6<br>*12,5* | 90×75× 8,0<br>*22,9* | 100×75× 9,5<br>*33,1* | 120×75× 9<br>*44,9* | 130×75×10,0<br>*56,9* | 140×65× 8<br>*88,1* |
| 4,8 | 75×65× 7,0<br>*14,9* | 90×75× 9,0<br>*26,2* | 120×75× 8,5<br>*42,3* | 130×75×10<br>*57,5* | 140×65× 8<br>*87,7* | 150×75× 8,5<br>*110* |
| 6,0 | 90×65× 6,0<br>*17,9* | 100×75× 9,5<br>*32,9* | 130×75× 9,5<br>*54,6* | 150×75× 9,5<br>*71,8* | 150×75× 8,5<br>*108* | 165×75× 8,5<br>*132* |
| 7,2 | 90×75× 8,0<br>*23,9* | 120×75× 8,5<br>*42,2* | 140×75× 9,5<br>*61,7* | 140×65× 8,5<br>*92,3* | 150×75× 9,5<br>*117* | 180×75× 8<br>*157* |
| 8,4 | 90×75× 9,0<br>*25,9* | 120×75× 9,5<br>*47,3* | 150×75×10<br>*74,1* | 150×75× 8,5<br>*109* | 165×75× 9<br>*138* | 180×75×10,5<br>*187* |
| 9,6 | 100×75× 9<br>*32,4* | 130×75× 9,5<br>*54,8* | 140×65× 8,5<br>*91,9* | 165×75× 8,5<br>*130* | 180×75× 8,5<br>*164* | 200×75× 9,5<br>*219* |
| 10,8 | 100×75×10<br>*34,6* | 140×75× 9,5<br>*61,3* | 150×75× 8,5<br>*108* | 165×75× 9,5<br>*140* | 180×75×10,5<br>*186* | 200×90×10,5<br>*234* |
| 12,0 | 100×75×10,5<br>*36,5* | 150×75× 9,5<br>*70,7* | 150×75× 9<br>*113* | 180×75× 8<br>*158* | 200×75× 9,5<br>*218* | 200×90×13<br>*269* |
| 13,2 | 120×75× 8,5<br>*41,7* | 150×75×10<br>*75,1* | 165×75× 8<br>*129* | 180×75×10,5<br>*186* | 200×90×10,5<br>*235* | *300* |
| 14,4 | 120×75× 9,5<br>*46,3* | 140×65× 8,0<br>*87,8* | 165×75× 9<br>*136* | 180×75×11<br>*194* | 200×90×12<br>*257* | *320* |
| 15,6 | 120×75×11<br>*53,8* | 140×65× 9<br>*94,2* | 180×75× 8<br>*156* | 200×75× 9,5<br>*219* | *296* | 230×90×12,5<br>*351* |
| 16,8 | 130×75×10<br>*56,9* | 150×75× 8,5<br>*107* | 180×75× 8,5<br>*165* | 200×90×10,5<br>*233* | *317* | *384* |
| 18,0 | 150×75× 8<br>*60,5* | 150×75× 9<br>*113* | 180×75×10,5<br>*185* | 200×90×12<br>*256* | 230×90×12<br>*342* | 250×90×12<br>*427* |

ANGLES — BULB ANGLES

## NOTES.—TABLE 38

1. **Depth** is to be measured at mid-length of the tunnel from the bulkhead deck at the centre line to the base of the tunnel.

2. **Correction for spacing.** If the spacing of the stiffeners differs from 915 mm. the Table modulus is to be modified in direct proportion.

3. Particulars of sections and moduli are given in Table 56.

| LENGTH OF STIFFENER | | NUMERAL | | | | | |
|---|---|---|---|---|---|---|---|
| | | NOT EXCEEDING 15 | 30 | 45 | 60 | 85 | 110 |
| | | ← — — — — — — SINGLE STIFFENERS — — — — — — → | | | | ← — — DOUBLE STIFFENERS — — → | |
| Metres | | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres |
| 2,4 | ANGLES | 100×75× 8,5 | 130×75× 9,0 | 150×75× 8,5 | 180×75× 9 | 150×75× 7,0 | 150×75× 9 |
| 3,0 | ANGLES | 130×75× 8,0 | 150×75× 8,0 | 165×75× 8,5 | 180×75×10 | 150×75× 7,5 | 150×75×10 |
| 3,6 | ANGLES | 130×75× 9,0 | 165×75× 8,0 | 180×75× 9 | 200×75×10 | 150×75× 8,5 | 165×75×10,5 |
| 4,2 | ANGLES | 130×75×10,0 | 165×75× 9,5 | 180×75×10,5 | 200×75×11,5 | 165×75× 8,5 | 180×75×10,5 |
| 4,8 | BULB ANGLES | 150×75× 9,0 | 180×75× 9,5 | 200×75×10,5 | 200×90×12,5 | 180×75× 9 | 200×75×10,5 |
| 5,4 | BULB ANGLES | 165×75× 9,0 | 200×75× 9,5 | 200×75×11,5 | 230×90×12 | 180×75×10 | 200×75×11,5 |
| 6,0 | BULB ANGLES | 180×75× 9,5 | 200×75×11 | 200×90×13 | 250×90×12,5 | 200×75×10 | 200×90×12 |
| 6,6 | BULB ANGLES | 180×75×11,0 | 200×90×12 | 230×90×12,5 | 280×90×14 | 200×75×11,5 | 230×90×12 |
| 7,2 | BULB ANGLES | 200×75×10,5 | 230×90×11 | 250×90×12,5 | 300×90×13,5 | 200×90×12 | 250×90×11,5 |
| 7,8 | BULB ANGLES | 200×90×11,0 | 250×90×11 | 280×90×12 | 300×90×13,5 | 230×90×11 | 250×90×13 |
| 8,4 | BULB ANGLES | 200×90×12,5 | 250×90×12 | 280×90×13 | 300×90×15 | 230×90×12 | 250×90×13,5 |
| 9,0 | BULB ANGLES | 230×90×12 | 250×90×13,5 | 280×90×14 | 200×90×11 | 250×90×11,5 | 280×90×13 |
| 9,6 | BULB ANGLES | 250×90×11 | 280×90×12 | 300×90×13,5 | 200×90×11,5 | 250×90×12,5 | 280×90×14 |

**NOTES.—TABLE 39**

1. **Length** of stiffener is to be measured between the top and bottom boundaries of the bulkhead.

2. **The numeral,** whether for stiffeners supporting deck beams, strong hatch end beams or deck transverses, is to be obtained as for pillars; *see* Table 31, notes 1 and 2.

3. **Arrangements with longitudinally framed decks.**—The stiffeners not supporting deck transverses are to have a modulus 25 per cent less than that derived from the column headed "Not exceeding 15". The ends of hold

| NUMERAL | | | | | LENGTH OF STIFFENER |
|---|---|---|---|---|---|
| 140 | 170 | 200 | 230 | 260 | |
| ← DOUBLE STIFFENERS → | | | | | |
| Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Metres |
| 150×75×10,5 | 165×75×10 | 180×75×11 | 200×75×10,5 | 200×90×11,5 | 2,4 |
| 165×75×10 | 180×75×10,5 | 200×75×10,5 | 200×90×11 | 200×90×12,5 | 3,0 |
| 180×75×10,5 | 200×75×11 | 200×90×11 | 200×90×12,5 | 230×90×12,5 | 3,6 |
| 200×75×10,5 | 200×75×11,5 | 230×90×11,5 | 230×90×12,5 | 250×90×13,5 | 4,2 |
| 200×90×11 | 230×90×11 | 250×90×11,5 | 250×90×13 | 280×90×12,5 | 4,8 |
| 200×90×12,5 | 230×90×12,5 | 250×90×13 | 280×90×12 | 280×90×14 | 5,4 |
| 230×90×12 | 250×90×12,5 | 280×90×12,5 | 280×90×13,5 | 300×90×13,5 | 6,0 |
| 250×90×12,5 | 280×90×12 | 280×90×13,5 | 300×90×13,5 | 300×90×15 | 6,6 |
| 250×90×13,5 | 280×90×13 | 300×90×13,5 | 300×90×15 | | 7,2 |
| 280×90×13 | 300×90×13 | 300×90×15 | | | 7,8 |
| 280×90×14 | 300×90×14,5 | | | | 8,4 |
| 300×90×13,5 | | | | | 9,0 |
| 300×90×14,5 | | | | | 9,6 |

BULB ANGLES

**NOTES.—TABLE 39** (*concluded*)

stiffeners are to be lugged or welded to the inner bottom and deck.

4. **Coal bunker bulkheads.** — The scantlings of stiffeners for bunker bulkheads, not supporting decks, are to be determined from the column headed "Not exceeding 15" for a spacing of 915 mm., but the modulus may be reduced by 25 per cent.

5. For end connections and constructional details *see* D 18.

# TABLE 40 STIFFENERS ON BOUNDARY BULKHEADS OF DEEP TANKS,

Spaced 610 mm. apart

| LENGTH OF STIFFENERS | | HEAD H METRES | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 0,9 | 1,2 | 1,5 | 1,8 | 2,4 | 3,0 | 3,6 | 4,2 |
| Metres | | MILLIMETRES *Modulus centimetres³* | | | | | | | |
| 1,5 | ANGLES | 75×75× 6<br>*13,5* | 75×75× 7,0<br>*15,5* | 75×75× 8,5<br>*18,7* | 75×75×10<br>*21,5* | 90×75×10<br>*29,2* | 100×75×10,5<br>*36,8* | *43,1* | *50,2* |
| 1,8 | ANGLES | 75×75× 7,5<br>*15,9* | 90×75× 7,5<br>*22,0* | 100×75× 7,5<br>*26,7* | 100×75× 9<br>*32,7* | *43,8* | 120×75×11<br>*53,4* | 150×75× 8,5<br>*64,1* | *73,2* |
| 2,1 | ANGLES | 90×75× 7,5<br>*22,0* | 100×75× 9<br>*32,2* | 100×75×11<br>*39,7* | 120×75× 9<br>*45,0* | 130×75×10,5<br>*61,0* | 140×75×11,5<br>*75,8* | *89,5* | 150×75× 7,5<br>*102* |
| 2,4 | ANGLES | 100×75× 8,5<br>*29,8* | 120×75× 8<br>*40,0* | 120×75×10<br>*49,8* | 130×75×10<br>*57,8* | 150×75×10,5<br>*78,2* | 150×75× 7<br>*97,7* | 150×75× 9,5<br>*116* | 165×75× 8<br>*129* |
| 2,7 | ANGLES | 100×75×10,5<br>*37,6* | *50,3* | 140×75× 9,5<br>*62,2* | 150×75×10<br>*74,5* | 150×75× 7<br>*98,2* | 150×75×10<br>*123* | 165×75× 9,5<br>*145* | 180×75× 9<br>*168* |
| 3,0 | ANGLES | *45,2* | 150×75× 8<br>*60,6* | 150×75×10,5<br>*78,0* | *91,3* | 150×75×10<br>*124* | 165×75×10,5<br>*152* | 180×75×10<br>*181* | 200×75× 9<br>*211* |
| 3,3 | ANGLES | *55,5* | *77,0* | 150×75×12<br>*89,3* | 150×75× 8,5<br>*110* | 165×75×10<br>*148* | 180×75×10<br>*182* | 200×75× 9<br>*214* | 200×75×11,5<br>*247* |
| 3,6 | ANGLES | 150×75× 9,5<br>*70,9* | 150×75×11,5<br>*85,5* | 150×75× 8,5<br>*109* | 165×75× 8<br>*128* | 180×75× 9<br>*171* | 200×75× 9<br>*211* | 200×75×11,5<br>*249* | *289* |
| 3,9 | ANGLES | 150×75×11<br>*80,7* | 150×75× 7,0<br>*97* | 150×75×10,5<br>*126* | 165×75×10,5<br>*150* | *200* | 200×75×11,5<br>*248* | *298* | 230×90×11<br>*340* |
| 4,2 | ANGLES | 150×75×11,5<br>*86,0* | 150×75× 9<br>*114* | 165×75× 9,5<br>*145* | 180×75× 9,5<br>*176* | 200×75×10,5<br>*237* | *293* | 230×90×12<br>*346* | *397* |
| 4,5 | BULB ANGLES | 150×75× 8<br>*104* | 165×75× 9<br>*138* | 180×75× 9,5<br>*173* | *203* | *276* | 230×90×12<br>*343* | 250×90×11<br>*399* | 250×90×13,5<br>*458* |
| 4,8 | BULB ANGLES | 150×75×10<br>*124* | 180×75× 8,5<br>*162* | *203* | 200×75×10,5<br>*236* | 230×90×11<br>*322* | *394* | 250×90×14<br>*460* | *519* |
| 5,1 | BULB ANGLES | 165×75× 9,5<br>*143* | 180×75×10,5<br>*189* | 200×75×10,5<br>*235* | 200×90×13<br>*268* | 230×90×13<br>*358* | 250×90×13<br>*450* | *527* | 280×90×14,5<br>*598* |
| 5,4 | BULB ANGLES | 180×75× 8,5<br>*163* | 200×75× 9<br>*216* | 200×90×13<br>*268* | *310* | 250×90×11<br>*402* | *517* | 280×90×14,5<br>*609* | 300×90×14<br>*700* |
| 5,7 | BULB ANGLES | 180×75×11<br>*190* | 200×75×11,5<br>*250* | *309* | 230×90×12,5<br>*353* | *472* | 280×90×14<br>*595* | 300×90×14<br>*703* | 300×100×100×14<br>*800* |
| 6,0 | BULB ANGLES | *218* | *286* | 230×90×12,5<br>*353* | 250×90×11<br>*405* | 280×90×12,5<br>*549* | 300×90×13,5<br>*687* | 300×100×100×14<br>*803* | 320×100×100×14,5<br>*908* |
| 6,3 | BULB ANGLES | 200×75×11<br>*245* | 230×90×11<br>*325* | 250×90×11<br>*403* | 250×90×13,5<br>*458* | *633* | 300×100×100×13,5<br>*787* | 320×100×100×15<br>*924* | 350×100×100×15,5<br>*1030* |
| 6,6 | BULB ANGLES | *277* | *368* | 250×90×13,5<br>*457* | *535* | 280×100×100×14<br>*720* | 320×100×100×14<br>*893* | 350×100×100×16<br>*1042* | 380×100×100×15,5<br>*1183* |
| 6,9 | BULB ANGLES | 230×90×11,0<br>*323* | 250×90×11,5<br>*417* | *535* | *615* | 300×100×100×14,5<br>*812* | 350×100×100×15<br>*1002* | 380×100×100×15,5<br>*1180* | 400×110×110×14,5<br>*1338* |
| 7,2 | BULB ANGLES | *375* | 250×90×14<br>*468* | 280×90×14<br>*589* | 300×90×14<br>*692* | 320×100×100×14,5<br>*916* | 380×100×100×14<br>*1118* | 400×110×110×14,5<br>*1333* | *1528* |

## NOTES.—TABLE 40

1. **Length of stiffeners** on bulkheads is to be measured as follows:—

(*a*) Where horizontal girders are not fitted:

between the top and bottom boundaries.

(*b*) Where horizontal girders are fitted:

(i) between the top boundary and the highest girder,

(ii) between girder and girder,

(iii) between the lowest girder and the bottom boundary.

On tunnels passing through deep tanks and having a curved top, the length of stiffeners is to be measured from the base of the tunnel to the top of the flat side.

2. **Head H** is to be taken as the greater of the two following values:—

(*a*) the distance in metres from the mid-point of length as defined above to the top of the tank.

Spaced 610 mm. apart

| HEAD H METRES 4,8 | 5,4 | 6,0 | 6,6 | 7,2 | 7,8 | 8,4 | | LENGTH OF STIFFENERS |
|---|---|---|---|---|---|---|---|---|
| MILLIMETRES *Modulus – centimetres³* | | | | | | | | Metres |
| 140×75× 8,5<br>*56,5* | 150×75× 8,5<br>*63,3* | 150×75× 9<br>*68,4* | 150×75× 9,5<br>*72,0* | *80,0* | *90,0* | 150×75× 8,5<br>*107* | BULB ANGLES | 1,5 |
| 150×75×11<br>*82,1* | *91,5* | 150×75× 7,5<br>*100* | 150×75× 8,5<br>*109* | 150×75× 9,5<br>*118* | 165×75× 8<br>*128* | 165×75× 9<br>*139* | | 1,8 |
| 150×75× 9<br>*114* | 165×75× 8<br>*128* | 165×75× 9,5<br>*141* | 180×75× 8<br>*157* | 180×75× 9<br>*168* | 180×75×10<br>*178* | 180×75×11,5<br>*189* | | 2,1 |
| 165×75×10,5<br>*153* | 180×75× 9<br>*169* | 180×75×10<br>*178* | *206* | 200×75× 9,5<br>*221* | 200×75×10,5<br>*235* | 200×75×11,5<br>*249* | | 2,4 |
| 180×75×11<br>*191* | 200×75× 9<br>*214* | 200×75×10,5<br>*237* | 200×75×12<br>*258* | *278* | *298* | *318* | | 2,7 |
| 200×75×10,5<br>*238* | 200×90×12,5<br>*264* | *293* | 230×90×11<br>*320* | 230×90×12<br>*340* | 230×90×13<br>*362* | *388* | | 3,0 |
| *277* | *306* | 230×90×12<br>*341* | 230×90×13<br>*364* | *388* | 250×90×12<br>*421* | 250×90×13,5<br>*455* | | 3,3 |
| 230×90×11<br>*322* | 230×90×13<br>*357* | *395* | 250×90×12<br>*428* | 250×90×14<br>*463* | *496* | *530* | | 3,6 |
| *383* | 250×90×12,5<br>*430* | 250×90×14<br>*464* | *507* | 280×90×12,5<br>*549* | 280×90×14<br>*588* | *621* | | 3,9 |
| 250×90×13,5<br>*452* | *506* | 280×90×12<br>*548* | 280×90×14<br>*590* | *636* | 300×90×13,5<br>*676* | 300×90×14,5<br>*716* | | 4,2 |
| *518* | 280×90×13,5<br>*574* | *630* | 300×90×13,5<br>*675* | 280×100×100×14,5<br>*734* | 300×100×100×13,5<br>*797* | 300×100×100×15,5<br>*840* | CHANNELS | 4,5 |
| *585* | *647* | 300×90×14,5<br>*710* | 300×100×100×13<br>*782* | 300×100×100×15,5<br>*843* | 320×100×100×14,5<br>*904* | 350×100×100×13,5<br>*966* | | 4,8 |
| 300×90×13<br>*670* | 280×100×100×15<br>*744* | 300×100×100×14,5<br>*819* | 320×100×100×14<br>*897* | 350×100×100×14<br>*970* | | | | 5,1 |
| 300×100×100×13<br>*778* | 320×100×100×13<br>*869* | 350×100×100×13,5<br>*959* | | | | | | 5,4 |
| 320×100×100×14,5<br>*905* | 350×100×100×15<br>*1013* | 380×100×100×14<br>*1113* | | | | | | 5,7 |
| 350×100×100×15,5<br>*1025* | 380×100×100×14,5<br>*1146* | 380×100×100×17,5<br>*1263* | | | | | | 6,0 |
| 380×100×100×16,5<br>*1170* | 400×110×110×14<br>*1308* | | | | | | | 6,3 |
| 400×110×110×14,5<br>*1347* | 400×110×110×18<br>*1490* | | | | | | | 6,6 |
| *1542* | | | | | | | | 6,9 |
| *1740* | | | | | | | | 7,2 |

**NOTES.—TABLE 40** *(concluded)*

(*b*) half the distance in metres from the mid-point of length as defined above to the top of the overflow.

3. **Correction for spacing.** Where the spacing of the stiffeners differs from 610 mm., the modulus is to be modified in direct proportion.

4. **Welded construction.** When the bulkhead plating, boundaries, stiffeners and end brackets are welded and the stiffeners are not supported by horizontal girders, the modulus of the stiffeners may, in general, be reduced by 15 per cent, but due consideration is to be given to stiffness and to the rigidity of the structure to which the end brackets are attached.

5. **Riveted end attachments** are to be in accordance with the requirements of Table 36.

6. Particulars of sections and moduli are given in Table 56.

# TABLE 41

## HORIZONTAL GIRDERS IN OIL FUEL BUNKERS

| NUMERAL | GIRDER | | NUMERAL | GIRDER | |
|---|---|---|---|---|---|
| | WEB PLATE | FACE AREA | | WEB PLATE | FACE AREA |
| | Millimetres | Centimetres$^2$ | | Millimetres | Centimetres$^2$ |
| 50 | 330× 8,5 | 9,0 | 650 | 1100×11,5 | 53,5 |
| 100 | 430× 8,5 | 15,0 | 700 | 1160×11,5 | 55,0 |
| 150 | 520× 9,0 | 21,0 | 750 | 1210×11,5 | 55,5 |
| 200 | 600× 9,0 | 25,0 | 800 | 1220×11,5 | 60,0 |
| 250 | 670× 9,5 | 26,5 | 850 | 1230×11,5 | 67,5 |
| 300 | 740× 9,5 | 28,5 | 900 | 1240×11,5 | 72,5 |
| 350 | 790×10,0 | 31,5 | 950 | 1250×11,5 | 78,0 |
| 400 | 840×10,5 | 34,0 | 1000 | 1290×11,5 | 78,0 |
| 450 | 880×11,0 | 41,5 | 1100 | 1370×12,0 | 78,0 |
| 500 | 940×11,0 | 46,0 | 1200 | 1440×12,5 | 78,0 |
| 550 | 980×11,0 | 49,5 | 1300 | 1530×12,5 | 78,0 |
| 600 | 1040×11,5 | 51,0 | | | |

### NOTES.—TABLE 41

1. **Numeral** = $s^2 \times b \times H$

where s = length, in metres, between centres of end brackets,

b = depth, in metres, between the centres of the two adjacent spans of stiffeners or frames supported by the girder,

H = for girders on bulkheads :—

the greater of the two following values :—

(*a*) the distance, in metres, from the girder to the top of the tank,

(*b*) half the distance, in metres, from the girder to the top of the overflow.

for girders supporting side frames :—

(*c*) the distance, in metres, from the girder to the upper deck at side. This distance need not, however, exceed 1,4d provided this is above the crown of the tank.

2. For tanks which exceed 9,15 metres in length the scantlings and arrangements will be specially considered.

3. The face area of girders derived from the Table may take the form of rolled sections, flanged girder plates or welded face plates, the width of the girder being the extreme width of the web plate.

4. For end connections and constructional details *see* D 2006 to D 2010.

## A—RIVETED

| BREADTH OF HATCHWAY | WEB PLATE — BEAM SPACING CENTRE TO CENTRE | | | | DOUBLE ANGLES ON EDGES OF BEAMS |
|---|---|---|---|---|---|
| | Metres 1,25 | Metres 1,50 | Metres 1,75 | Metres 2,00 | |
| Metres | Millimetres *Modulus—centimetres³* | | | | Millimetres |
| 3 | *240* | *310* | 255× 7,5 *585* | 285× 8 *705* | 75×75×10 |
| 3,5 | *385* | *420* | 270× 8 *670* | 330× 8,5 *869* | 75×75×10 |
| 4 | *475* | 260× 8 *640* | 320× 8,5 *860* | 350× 9 *995* | 75×75×10,5 |
| 4,5 | 245×8 *660* | 310× 8 *910* | 350× 9 *1100* | 380× 9,5 *1245* | 90×75×10,5 |
| 5 | 330×8 *980* | 375× 8 *1165* | 410× 9 *1360* | 455× 9,5 *1525* | 90×75×10,5 |
| 5,5 | 365×8,5 *1270* | 405× 9 *1475* | 450× 9 *1690* | 485× 9,5 *1870* | 100×75×11 |
| 6 | 390×8,5 *1380* | 450× 9 *1680* | 495× 9,5 *1915* | 535× 9,5 *2130* | 100×75×11 |
| 6,5 | 410×9 *1580* | 475× 9 *1925* | 530× 9,5 *2245* | 570×10 *2505* | 100×75×12 |
| 7 | 435×9 *1840* | 500× 9,5 *2215* | 560×10 *2615* | 610×10,5 *2950* | 120×90×11 |
| 7,5 | 455×9 *2125* | 520× 9,5 *2540* | 580×10 *2980* | 635×10,5 *3385* | 130×90×11,5 |
| 8 | 475×9 *2430* | 540× 9,5 *2875* | 605×10 *3350* | 660×10,5 *3795* | 140×90×12 |
| 8,5 | 495×9,5 *2770* | 560× 9,5 *3240* | 625×10 *3750* | 685×10,5 *4275* | 150×90×12,5 |
| 9 | 515×9,5 *3015* | 575×10 *3510* | 640×10,5 *4035* | 700×11 *4580* | 150×90×13 |

## B—RIVETED

| | | | | | |
|---|---|---|---|---|---|
| 3 | *181* | *234* | *262* | *293* | 75×75×10 |
| 3,5 | *236* | *301* | *347* | *422* | 75×75×10 |
| 4 | *301* | *375* | 225× 7,5 *525* | 260× 8 *640* | 75×75×10,5 |
| 4,5 | *505* | *555* | 265× 8 *725* | 295× 8 *850* | 90×75×10,5 |
| 5 | 285×7,5 *805* | 290× 7,5 *825* | 310× 8 *900* | 340× 8,5 *1040* | 90×75×10,5 |
| 5,5 | 290×7,5 *900* | 310× 8 *1000* | 345× 8,5 *1180* | 380× 9 *1350* | 100×75×11 |
| 6 | 310×8 *995* | 330× 8,5 *1100* | 385× 9 *1360* | 425× 9 *1560* | 100×75×11 |
| 6,5 | 320×8 *1125* | 350× 8,5 *1265* | 410× 9 *1575* | 455× 9 *1810* | 100×75×12 |
| 7 | 335×8,5 *1285* | 365× 8,5 *1450* | 430× 9 *1810* | 475× 9,5 *2075* | 120×90×11 |
| 7,5 | 345×8,5 *1460* | 375× 8,5 *1645* | 450× 9 *2075* | 490× 9,5 *2375* | 130×90×11,5 |
| 8 | 355×8,5 *1645* | 390× 8,5 *1855* | 470× 9 *2390* | 515× 9,5 *2720* | 140×90×12 |
| 8,5 | 365×8,5 *1855* | 405× 9 *2125* | 485× 9,5 *2715* | 535× 9,5 *3065* | 150×90×12,5 |
| 9 | 385×8,5 *2050* | 425× 9 *2355* | 505× 9,5 *2950* | 555× 9,5 *3310* | 150×90×13 |

*For notes see page 158*

# TABLE 43 C HATCHWAY BEAMS

## C—WELDED

| DEPTH OF BEAM OVER FACE PLATES | BASIC WEB THICKNESS | * CORRECTION TO MODULUS PER 1 MM. VARIATION IN WEB THICKNESS | BASIC FLANGE THICKNESS | † CORRECTION TO MODULUS PER 1 MM. VARIATION IN FLANGE THICKNESS | AREA OF EACH FACE PLATE SQUARE CENTIMETRES | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 |
| | | | | | MODULUS | | | | | | | | | | | |
| Millimetres | Millimetres | Centimetres³ | Millimetres | Centimetres³ | <— | — | — | — | — | — | —Centimetres³— | — | — | — | — | —> |
| **200** | 9 | *4* | 15 | *7* | *379* | *465* | *551* | *636* | | | | | | | | |
| **250** | 9 | *7* | 15,5 | *7* | *503* | *613* | *722* | *832* | | | | | | | | |
| **300** | 10 | *10* | 17,5 | *8* | | *770* | *902* | *1035* | *1168* | | | | | | | |
| **350** | 10 | *15* | 18 | *9* | | *936* | *1093* | *1250* | *1408* | *1564* | | | | | | |
| **400** | 11,5 | *20* | 20 | *11* | | | *1307* | *1488* | *1668* | *1848* | *2028* | | | | | |
| **450** | 11,5 | *25* | 20,5 | *13* | | | *1522* | *1727* | *1931* | *2136* | *2340* | *2547* | *2751* | | | |
| **500** | 12,5 | *31* | 22,5 | *14* | | | | | *2214* | *2442* | *2671* | *2898* | *3127* | *3356* | | |
| **550** | 12,5 | *38* | 23 | *15* | | | | | *2505* | *2758* | *3009* | *3263* | *3517* | *3770* | *4019* | |
| **600** | 14 | *46* | 25 | *17* | | | | | | *3128* | *3403* | *3678* | *3954* | *4229* | *4507* | *4781* |

* When the thickness of the web is increased, the modulus is to be increased by the appropriate correction
† When the thickness of the flange is increased, the modulus is to be reduced by the appropriate correction

### NOTES.—TABLE 43

1. **Scantlings** of riveted hatchway beams are to be determined from the Table as follows :—

For hatchways requiring coamings 610 mm. in height (D 2301 to D 2302), in ships 61 metres or more in length ... ... ... ... **A**
in ships 30,5 metres or less in length ... ... **B**
(For intermediate lengths scantlings are to be determined by interpolation.)

For hatchways requiring coamings 457 mm. in height, or less, except in cargo spaces ... ... **B**
For hatchways in cargo spaces (*see also* note 4) ... **A**
For hatchways in accommodation spaces ... ... **B**

2. The Table depth of hatchway beams is to be measured at the mid-length from the top of the upper mounting angles to the bottom of the lower mounting angles or bulb plate. The depth of the ends may be half that at the centre but is not to be less than 150 mm. Alternative arrangements may be adopted if suitable strength is provided at the ends of the webs. The larger flange of the mountings is to be fitted horizontally.

3. Scantlings of welded hatchway beams may be obtained from **C** on the basis of modulus equivalent to the requirements of **A** or **B**. The width of the face plates is to be sufficient to provide the minimum hatch bearing surface required by D 2313.

4. Where the 'tween deck height in cargo spaces and trunked hatchways (*see* D 2330) exceeds 2,6 metres the modulus of the hatchway beams is to be increased in direct proportion.

5. For construction details *see* D 2310 to D 2316.
For riveting and welding *see* Table 52 H.

6. Where built steel hatchway covers are fitted, the scantlings are to be in accordance with the following formulæ :

| | Type A (Note 1) | Type B (Note 1) |
|---|---|---|
| Section Modulus of stiffeners (including plating) in cm.³ | $23\ SL^2$ | $17\ SL^2$ |
| Moment of inertia of stiffeners (including plating) in cm.⁴ | $39\ SL^3$ | $29\ SL^3$ |

Where L = unsupported span of stiffeners, in metres.
S = spacing of stiffeners, in metres.

Thickness of plating in mm. $6{,}5+\frac{s-610}{150}$ $6+\frac{s-610}{200}$

Where s = spacing of stiffeners, in mm.
For pontoon hatch covers, *see* D 2326.

7. Where deck cargoes are to be carried on upper deck hatches the scantlings of Type A and B hatches will require to be increased if the equivalent height (at 1,39 cubic metres per 1000 kg.) exceeds 2,6 metres and 1,98 metres respectively. (*See also* D 1113).

# DIAMETER OF RUDDER HEADS

TABLE 44

| NUMERAL | SEA SPEED IN KNOTS | | | | | | |
|---|---|---|---|---|---|---|---|
| | 10 and below | 12 | 14 | 16 | 18 | 20 | 22 |
| | DIAMETER OF RUDDER HEAD (Millimetres) | | | | | | |
| **85** | 90 | 95 | 100 | 110 | | | |
| **110** | 100 | 105 | 115 | 120 | | | |
| **140** | 110 | 115 | 120 | 135 | | | |
| **170** | 115 | 120 | 130 | 140 | | | |
| **200** | 120 | 130 | 135 | 145 | | | |
| **230** | 130 | 135 | 140 | 155 | | | |
| **260** | 135 | 140 | 150 | 160 | 175 | | |
| **290** | 140 | 150 | 160 | 175 | 190 | | |
| **340** | 150 | 160 | 170 | 185 | 195 | | |
| **400** | 160 | 165 | 180 | 190 | 205 | 215 | |
| **455** | 170 | 180 | 190 | 205 | 215 | 230 | |
| **540** | 185 | 190 | 205 | 215 | 230 | 240 | |
| **620** | 195 | 205 | 215 | 230 | 240 | 255 | 275 |
| **735** | 210 | 215 | 230 | 240 | 255 | 265 | 285 |
| **850** | 215 | 225 | 235 | 250 | 265 | 280 | 300 |
| **990** | 230 | 235 | 250 | 260 | 280 | 290 | 310 |
| **1130** | 240 | 240 | 260 | 275 | 290 | 305 | 330 |
| **1280** | 255 | 255 | 265 | 280 | 305 | 320 | 345 |
| **1450** | 265 | 265 | 280 | 290 | 315 | 330 | 355 |
| **1615** | 280 | 280 | 290 | 305 | 330 | 345 | 375 |
| **1815** | 290 | 290 | 305 | 320 | 345 | 365 | 395 |
| **2040** | 305 | 305 | 320 | 330 | 355 | 380 | 405 |
| **2265** | 320 | 320 | 330 | 345 | 370 | 395 | 420 |
| **2520** | 330 | 330 | 345 | 355 | 380 | 405 | 435 |
| **2775** | 345 | 345 | 355 | 370 | 395 | 420 | 450 |
| **3060** | 355 | 355 | 370 | 390 | 415 | 440 | 465 |
| **3340** | 370 | 370 | 380 | 405 | 430 | 460 | 485 |
| **3655** | 380 | 380 | 395 | 420 | 445 | 470 | 495 |
| **3965** | 395 | 395 | 405 | 430 | 455 | 480 | 510 |

## NOTES.—TABLE 44

1. **Numeral.**—(*a*) The numeral $= 100 \times A \times D$ where :

A = total area of rudder in square metres, including balanced portion, if any.

D = distance in metres of centre of gravity of area A from the centre line of the pintles.

(*b*) For balanced rudders the numeral is not to be less than 80 per cent of that derived from the part of the rudder abaft the centre line of the pintles.

2. For rudders strengthened for navigation in ice *see* D 1006, D 1014 and D 1022.

3. Where steel complying with P 614, third sub-paragraph, or scrap material (*see* D 2603) is used the diameter of rudder head is to be increased by 5 per cent.

# TABLE 45

## SINGLE PLATE RUDDERS

| DIAMETER OF RUDDER HEAD TABLE 44 | ARMS—SPACED 1220 mm. BETWEEN CENTRES | | | | PLATE | DIAMETER OF RIVETS SPACED 4½ DIAMETERS APART CENTRE TO CENTRE |
|---|---|---|---|---|---|---|
| | BREADTH | THICKNESS | | | | |
| | | AT MAINPIECE | ROUND MAINPIECE | AT ENDS | | |
| Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres |
| **75** | 75 | 50 | 35 | 19 | 20 | 22 |
| **100** | 100 | 60 | 45 | 22 | 20,5 | 25 |
| **125** | 125 | 70 | 54 | 25 | 21 | 28 |
| **150** | 140 | 80 | 57 | 25 | 21,5 | 28 |
| **175** | 150 | 90 | 64 | 25 | 22 | 28 |
| **205** | 165 | 100 | 70 | 25 | 22,5 | 32 |
| **230** | 175 | 110 | 76 | 25 | 23 | 32 |
| **255** | 190 | 115 | 83 | 28 | 23,5 | 32 |
| **280** | 205 | 125 | 89 | 28 | 24 | 32 |
| **305** | 215 | 135 | 92 | 28 | 24,5 | 32 |
| **330** | 220 | 145 | 95 | 28 | 24,5 | 32 |
| **355** | 230 | 150 | 98 | 28 | 25 | 32 |
| **380** | 235 | 160 | 102 | 28 | 25 | 32 |

### NOTES.—TABLE 45

**Corrections for spacing of arms.**—The breadth of the arms is to be modified directly as the spacing.

The thickness of the plate is to be modified with the spacing at the rate of 1 mm. for every 100 mm. increase or reduction from 1220 mm.

# DOUBLE PLATE RUDDERS

TABLE 46

## SIDE PLATES

| DIAMETER OF RUDDER HEAD TABLE 44 | SPACING OF ARMS BETWEEN CENTRES MILLIMETRES | | | SOLID FRAMES |
|---|---|---|---|---|
| | FORGED & CAST FRAMES | | | DIAMETER OF RIVETS SPACED 4½ DIAMETERS APART CENTRE TO CENTRE |
| | 915 | 1220 | 1525 | |
| | PLATE FRAMES | | | |
| | 610 | 915 | 1220 | |
| Millimetres | Millimetres | Millimetres | Millimetres | Millimetres |
| 100 | 9,0 | 11,5 | | 19 |
| 125 | 9,5 | 12,0 | | 19 |
| 150 | 9,5 | 12,5 | | 22 |
| 175 | 10,0 | 12,5 | 15,0 | 22 |
| 205 | 10,5 | 13,0 | 15,5 | 22 |
| 230 | 11,0 | 13,5 | 16,0 | 22 |
| 255 | 11,0 | 13,5 | 16,5 | 25 |
| 280 | 11,5 | 14,0 | 16,5 | 25 |
| 305 | 12,0 | 14,5 | 17,0 | 25 |
| 330 | 12,0 | 14,5 | 17,5 | 25 |
| 355 | 12,5 | 15,0 | 18,0 | 25 |
| 380 | 13,0 | 15,5 | 18,5 | 25 |

### NOTES.—TABLE 46

1. **Plate thickness.**—When the ratio of the fore and aft dimension to the vertical dimension of the unsupported panels of plating exceeds 3 : 2 an additional vertical diaphragm is to be fitted.

The thickness of side plates of rudder with a plate frame may require to be increased in way of the vertical webs which replace the mainpiece.

The thickness of the nose plate is not to be less than that required for the side plates at a 1220 millimetres spacing of plate frames.

2. **Plate frames.**—Horizontal webs and vertical webs not replacing the mainpiece are to have the same thickness as the side plates, but the plates forming the top and bottom of the rudder are to be of increased thickness.

Vertical webs replacing the mainpiece are to have a thickness equal to twice the Table thickness of side plates for 760 mm. spacing.

# TABLE 47

## RUDDER PINTLES

### ONE OR TWO PINTLES
BALANCED OR UNBALANCED RUDDERS

| AREA SUPPORTED (*See* NOTE 1) | SEA SPEED IN KNOTS | | | | | |
|---|---|---|---|---|---|---|
| | 12 and below | 14 | 16 | 18 | 20 | 22 |
| | DIAMETER OF PINTLES | | | | | |
| Metres$^2$ | < Millimetres > | | | | | |
| 1 | 80 | 90 | 100 | | | |
| 2 | 115 | 125 | 140 | | | |
| 4 | 155 | 160 | 170 | 195 | 215 | |
| 6 | 195 | 195 | 205 | 225 | 250 | 280 |
| 8 | 205 | 205 | 215 | 240 | 270 | 305 |
| 10 | | 225 | 235 | 255 | 290 | 335 |
| 12 | | 240 | 250 | 280 | 315 | 365 |
| 14 | | 260 | 270 | 300 | 335 | 390 |
| 16 | | | 290 | 325 | 365 | 420 |
| 18 | | | 315 | 345 | 395 | 450 |

### THREE OR MORE PINTLES
UNBALANCED RUDDERS

| AREA SUPPORTED (*See* NOTE 1) | SEA SPEED IN KNOTS | | | | |
|---|---|---|---|---|---|
| | 12 and below | 14 | 16 | 18 | 20 |
| | DIAMETER OF PINTLES | | | | |
| Metres$^2$ | < Millimetres > | | | | |
| 1 | 65 | 75 | 85 | | |
| 2 | 105 | 115 | 125 | | |
| 3 | 130 | 140 | 150 | 175 | |
| 4 | 160 | 165 | 175 | 190 | |
| 5 | 180 | 180 | 190 | 210 | 235 |
| 6 | 195 | 195 | 205 | 225 | 250 |

### NOTES.—TABLE 47

1. **Area supported.**—When there is one pintle only the area supported is that below a horizontal line half way between the pintle and the top of the rudder.

Where there are two pintles the areas supported are those bounded by a horizontal line midway between the two pintles.

Where there are more than two pintles the area supported is to be taken as the total area of the rudder divided by the number of pintles.

2. **Pintles.**—The diameter of pintles obtained from the Table is to be measured outside the liner, if fitted.

The bearing length is to be 20 per cent greater than the diameter, except that where three or more pintles are fitted, the bearing length of the bottom pintle need only be equal to the diameter.

The length of pintle housing in the rudder gudgeons is to be 20 per cent greater than the diameter of the pintle.

Pintles are to be fitted as taper bolts, the taper not being greater than 1 in 12 on the radius.

| DIAMETER OF RUDDER HEAD TABLE 44 | HORIZONTAL COUPLING | | VERTICAL COUPLING | | SCARPHED COUPLING | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6 BOLTS | | 8 BOLTS | | | WIDTH OF SCARPHS | | BOLTS | | |
| | MEAN DISTANCE OF CENTRES OF BOLTS FROM CENTRE OF COUPLING | DIAMETER OF BOLTS AND THICKNESS OF FLANGES | WIDTH OF COUPLING | DIAMETER OF BOLTS AND THICKNESS OF FLANGES | LENGTH OF SCARPH | AT TOP | AT BOTTOM | NUMBER | | DIAMETER |
| | | | | | | | | TOTAL | IN TOP ROW | |
| Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | | | Millimetres |
| **90** | 100 | 28 | | | | | | | | |
| **95** | 105 | 28 | | | | | | | | |
| **100** | 110 | 32 | | | | | | | | |
| **110** | 110 | 32 | | | | | | | | |
| **115** | 115 | 35 | 305 | 35 | 345 | 230 | 380 | 6 | 2 | 38 |
| **120** | 115 | 35 | 305 | 35 | 345 | 230 | 380 | 6 | 2 | 38 |
| **125** | 115 | 35 | 305 | 35 | 345 | 230 | 380 | 6 | 2 | 38 |
| **135** | 120 | 38 | 305 | 38 | 345 | 230 | 380 | 6 | 2 | 38 |
| **140** | 125 | 38 | 320 | 38 | 355 | 240 | 395 | 6 | 2 | 41 |
| **145** | 135 | 38 | 330 | 38 | 370 | 255 | 410 | 6 | 2 | 44 |
| **150** | 140 | 41 | 345 | 41 | 385 | 265 | 425 | 6 | 2 | 48 |
| **160** | 145 | 44 | 355 | 44 | 400 | 280 | 440 | 6 | 2 | 51 |
| **165** | 150 | 48 | 370 | 48 | 415 | 290 | 455 | 6 | 2 | 54 |
| **170** | 160 | 48 | 385 | 48 | 430 | 300 | 475 | 6 | 2 | 54 |
| **180** | 165 | 51 | 400 | 51 | 445 | 310 | 495 | 6 | 2 | 57 |
| **185** | 170 | 54 | 415 | 54 | 460 | 325 | 515 | 6 | 2 | 57 |
| **190** | 180 | 54 | 425 | 54 | 475 | 335 | 535 | 7 | 2 | 54 |
| **195** | 185 | 57 | 440 | 57 | 495 | 345 | 545 | 7 | 2 | 54 |
| **205** | 190 | 60 | 455 | 60 | 510 | 355 | 560 | 7 | 2 | 57 |
| **215** | 195 | 63 | 480 | 63 | 540 | 380 | 610 | 7 | 2 | 63 |
| **230** | 205 | 70 | 510 | 70 | 570 | 400 | 635 | 7 | 2 | 67 |
| **240** | 215 | 73 | 540 | 73 | 605 | 425 | 665 | 7 | 2 | 70 |
| **255** | 230 | 76 | 570 | 76 | 635 | 445 | 700 | 7 | 2 | 73 |
| **265** | 240 | 79 | 600 | 79 | 665 | 470 | 735 | 8 | 2 | 73 |
| **280** | 255 | 83 | 630 | 83 | 700 | 490 | 765 | 8 | 2 | 76 |
| **290** | 265 | 86 | 660 | 86 | 730 | 515 | 800 | 8 | 2 | 79 |
| **305** | 275 | 89 | 685 | 89 | 760 | 535 | 840 | 8 | 2 | 83 |
| **320** | 285 | 92 | 710 | 92 | 795 | 635 | 875 | 9 | 3 | 83 |
| **330** | 300 | 95 | 735 | 95 | 825 | 660 | 915 | 9 | 3 | 83 |
| **345** | 310 | 98 | 765 | 98 | 855 | 685 | 950 | 9 | 3 | 86 |
| **355** | 320 | 102 | 795 | 102 | 890 | 710 | 985 | 9 | 3 | 92 |
| **370** | 330 | 105 | 825 | 105 | 920 | 735 | 1015 | 9 | 3 | 95 |
| **380** | 345 | 108 | 850 | 108 | 950 | 760 | 1040 | 9 | 3 | 98 |

**NOTES.—TABLE 48**

1. The width of material in the flanges, or palms of scarphs, outside the bolt holes is not to be less than two thirds of the diameter of the bolt.

2. In scarphed couplings the athwartship dimension at the top of the scarph is not to be less than the diameter of the rudder head. The thickness of the tips of the palms is not to be less than 13 per cent of the diameter of the rudder head.

# TABLE 49 STEERING CHAINS, RODS, QUADRANTS AND TILLERS

| DIAMETER OF RUDDER HEAD TABLE 44 | DIAMETER OF WROUGHT IRON CHAINS | DIAMETER OF RODS | RADIUS OF QUADRANT | BOSS OF QUADRANT | | QUADRANTS AND TILLERS | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Depth | Outside diameter | Size of arms at twice the diameter of rudder head from centre of rudder head | | |
| | | | | | | One arm | Two arms | Three arms |
| Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres |
| **90** | 14,5 | 16 | 965 | 90 | 160 | 90× 65 | | |
| **95** | 14,5 | 16 | 990 | 95 | 170 | 100× 65 | | |
| **100** | 16 | 17,5 | 1015 | 100 | 185 | 110× 65 | | |
| **110** | 17,5 | 19 | 1040 | 110 | 190 | 115× 70 | | |
| **115** | 17,5 | 19 | 1065 | 115 | 205 | 125× 70 | 95× 55 | |
| **120** | 19 | 20,5 | 1090 | 120 | 215 | 135× 70 | 100× 55 | |
| **125** | 19 | 20,5 | 1115 | 125 | 230 | 140× 75 | 110× 65 | |
| **135** | 20,5 | 22 | 1145 | 135 | 235 | 145× 75 | 115× 65 | |
| **140** | 20,5 | 24 | 1170 | 140 | 250 | 150× 85 | 120× 65 | |
| **145** | 22 | 24 | 1195 | 145 | 260 | 160× 85 | 125× 65 | |
| **150** | 22 | 25,5 | 1220 | 150 | 275 | 165× 90 | 135× 70 | |
| **160** | 24 | 27 | 1245 | 160 | 285 | 170× 90 | 140× 70 | |
| **165** | 24 | 27 | 1270 | 165 | 300 | 180× 95 | 140× 75 | |
| **170** | 25,5 | 29 | 1295 | 170 | 305 | 185× 95 | 145× 75 | |
| **180** | 25,5 | 32 | 1320 | 180 | 320 | 190×100 | 150× 85 | |
| **185** | 27 | 32 | 1345 | 185 | 330 | 195×110 | 150× 85 | |
| **190** | 27 | 33,5 | 1370 | 190 | 345 | 205×115 | 160× 90 | |
| **195** | 29 | 35 | 1395 | 195 | 355 | 210×115 | 160× 95 | |
| **205** | 30,5 | 35 | 1420 | 205 | 370 | 215×120 | 165×100 | 145× 90 |
| **215** | 32 | 38 | 1525 | 215 | 385 | 230×125 | 180×100 | 150× 95 |
| **230** | 33,5 | 40 | 1625 | 230 | 410 | 240×135 | 190×110 | 165× 95 |
| **240** | 35 | 42,5 | 1725 | 240 | 430 | 255×145 | 205×115 | 180×100 |
| **255** | 36,5 | 44,5 | 1830 | 255 | 445 | 265×150 | 215×115 | 190×100 |
| **265** | 38 | 47,5 | 1930 | 265 | 480 | 280×160 | 230×120 | 205×100 |
| **280** | 40 | 49 | 2030 | 280 | 500 | 290×170 | 240×125 | 210×115 |
| **290** | 41,5 | 49 | 2135 | 290 | 525 | 305×180 | 255×135 | 215×125 |
| **305** | 41,5 | 51 | 2235 | 305 | 545 | 320×190 | 265×140 | 230×125 |
| **320** | | | 2340 | 320 | 570 | 330×190 | 280×140 | 240×125 |
| **330** | | | 2440 | 330 | 595 | 345×190 | 285×145 | 255×125 |
| **345** | | | 2440 | 345 | 620 | 355×205 | 290×150 | 255×135 |
| **355** | | | 2440 | 355 | 640 | 370×205 | 305×150 | 265×135 |
| **370** | | | 2440 | 370 | 665 | 380×215 | 310×165 | 265×140 |
| **380** | | | 2440 | 380 | 685 | 395×215 | 325×165 | 280×140 |

**NOTE.—TABLE 49**

Where special steel short link chains (*see* P 1301 Grade III) are used, the diameter given in column 2 above may be reduced as follows :—

| *Table size* | *Reduction* |
|---|---|
| *mm.* | *mm.* |
| 25 and below | 1,5 |
| 25,5 — 30,5 | 3 |
| 31 — 41 | 4,5 |

# BOLTS FOR BOLTED TILLERS AND QUADRANTS — TABLE 50

| DIAMETER OF RUDDER HEAD TABLE 44 | ONE BOLT EACH SIDE | | TWO BOLTS EACH SIDE | | FOUR BOLTS EACH SIDE | | | THICKNESS OF COUPLING |
|---|---|---|---|---|---|---|---|---|
| | Diameter | Distance centre to centre | Diameter | Distance centre to centre | Diameter | Inner bolts centre to centre | Outer bolts centre to centre | |
| Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres |
| **90** | 38 | 280 | 32 | 254 | 19 | 215 | 345 | 35 |
| **100** | 44 | 305 | 35 | 280 | 22 | 240 | 380 | 38 |
| **115** | 51 | 330 | 38 | 305 | 25 | 265 | 420 | 41 |
| **125** | 57 | 355 | 44 | 330 | 29 | 290 | 455 | 44 |
| **140** | 63 | 380 | 48 | 355 | 32 | 320 | 510 | 47 |
| **150** | 70 | 420 | 51 | 380 | 35 | 345 | 560 | 50 |
| **165** | 76 | 455 | 54 | 405 | 38 | 380 | 610 | 50 |
| **180** | 83 | 480 | 57 | 430 | 41 | 405 | 650 | 55 |
| **190** | 89 | 520 | 63 | 470 | 44 | 430 | 700 | 55 |
| **205** | 95 | 560 | 67 | 510 | 48 | 470 | 750 | 65 |
| **215** | 98 | 585 | 70 | 535 | 51 | 495 | 800 | 65 |
| **230** | 102 | 610 | 73 | 560 | 54 | 520 | 850 | 70 |
| **240** | | | 76 | 595 | 54 | 545 | 875 | 70 |
| **255** | | | 83 | 620 | 57 | 570 | 915 | 75 |
| **265** | | | 86 | 660 | 60 | 610 | 965 | 75 |
| **280** | | | 92 | 685 | 63 | 635 | 1015 | 75 |
| **290** | | | 95 | 725 | 67 | 660 | 1065 | 75 |
| **305** | | | 98 | 750 | 70 | 685 | 1105 | 85 |
| **330** | | | 108 | 815 | 76 | 750 | 1205 | 85 |
| **355** | | | 115 | 875 | 79 | 815 | 1295 | 85 |
| **380** | | | 123 | 940 | 86 | 865 | 1370 | 85 |

# TABLE 51

## MASTS AND DERRICK POSTS

### DIAMETER AND THICKNESS AT DECK

### STAYED

| LENGTH OF MAST OR POST | NO DERRICKS | WORKING LOAD OF DERRICKS | |
|---|---|---|---|
| | | 4000 Kg. | 8000 Kg. |
| Metres | Millimetres | Millimetres | Millimetres |
| 9 | 305×6 | 460× 7,5 | 510× 7,5 |
| 10,5 | 355×6,5 | 510× 7,5 | 555× 8 |
| 12 | 405×7 | 560× 7,5 | 605× 8,5 |
| 13,5 | 450×7,5 | 585× 8 | 635× 9 |
| 15 | 495×8 | 610× 8,5 | 655× 9,5 |
| 16,5 | 545×8,5 | 645× 9,5 | 705×10,0 |
| 18 | 600×9 | 705×10,0 | 765×10,5 |

### UNSTAYED

| LENGTH OF MAST OR POST | WORKING LOAD OF DERRICKS | |
|---|---|---|
| | 4000 Kg. | 8000 Kg. |
| Metres | Millimetres | Millimetres |
| 6 | 610× 9 | 610×15 |
| 7,5 | 660× 9,5 | 660×16,5 |
| 9 | 710×10 | 710×18,0 |
| 10,5 | 750×10 | 750×18,0 |

**NOTES.—TABLE 51**

1. **Length** of mast or derrick post is to be measured from deck to hounds. Tops of small mast houses and derrick plates are not to be regarded as the deck for this purpose, unless the structure is adequately strengthened.

2. **Working load** of derricks is defined in D 2801 to D 2802.

3. The diameter and thickness of masts and derrick posts at the hounds are to be 85 per cent of the scantlings at the deck.

## DIAMETER AND SPACING OF RIVETS AND BREADTHS OF END LAPS, BUTT STRAPS AND SEAMS

| THICKNESS OF PLATES:— | Millimetres Not exceeding 9 | Millimetres Above 9 and not exceeding 12,5 | Millimetres Above 12,5 and not exceeding 18,5 | Millimetres Above 18,5 and not exceeding 24 | Millimetres Above 24 and not exceeding 29 | Millimetres Above 29 and not exceeding 32 |
|---|---|---|---|---|---|---|
| DIAMETER OF RIVETS:— | 16 | 19 | 22 | 25 | 28 | 31 |
| SPACING IN DIAMETERS | SPACING IN MILLIMETRES | | | | | |
| 3½ | 55 | 65 | 80 | 90 | 100 | 110 |
| 4 | 65 | 75 | 90 | 100 | 115 | 125 |
| 4½ | 70 | 85 | 100 | 115 | 125 | 140 |
| 5 | 80 | 95 | 110 | 125 | 145 | 155 |
| 5½ | 90 | 105 | 125 | 140 | 155 | — |
| 6 | 95 | 115 | 135 | 150 | 170 | — |
| 6½ | 100 | 125 | 145 | 165 | — | — |
| 7 | 115 | 135 | 160 | 180 | — | — |

### BREADTHS OF END LAPS, BUTT STRAPS AND SEAMS

| | | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres | Millimetres |
|---|---|---|---|---|---|---|---|
| END LAPS | Single Riveted ... | 65 | 75 | — | — | — | — |
| | Double Riveted ... | 110 | 125 | 150 | — | — | — |
| | Treble Riveted ... | 150 | 190 | 230 | 265 | 305 | 310 |
| | Quadruple Riveted ... | — | — | 305 | 355 | 405 | 420 |
| | Quintuple Riveted ... | — | — | 380 | 445 | 510 | 530 |
| BUTT STRAPS* | Single Riveted ... | 115 | 135 | — | — | — | — |
| | Double Riveted ... | 205 | 250 | 285 | — | — | — |
| | Treble Riveted ... | — | 360 | 425 | 485 | 545 | 560 |
| | Quadruple Riveted ... | — | — | 560 | 635 | 720 | 745 |
| SEAMS | Single Riveted ... | 55 | 65 | 75 | 90 | — | — |
| | Double Riveted ... | 95 | 115 | 135 | 150 | 170 | 175 |
| | Treble Riveted ... | — | — | — | 215 | 240 | 250 |

*Single butt straps are to be 25 per cent thicker than the plates to be connected. Where double butt straps are fitted the thickness of the countersunk strap is to be 70 per cent and the thickness of the strap on the opposite side is to be 60 per cent of the thickness of the plates to be connected.

### NOTES.—TABLE 52 A

1. The diameter of rivets in seams of keel, sheerstrake, deck stringer, middle line strake of inner bottom and margin plate is to be regulated by the thickness of the adjacent plating.

2. Rivets are to be kept sufficiently clear of edges of plating and of each other, and the distance from the centre of rivet holes to the edges of the plating, end laps or butt straps is not to be less than one and a half rivet diameters.

3. The distance between the centres of consecutive rows of rivets is to be three and a half diameters in end laps, three diameters in butt straps and two and a half diameters in seams.

# TABLE 52 B

# RIVETING AND WELDING

## B

## END LAPS AND SEAMS OF SHELL PLATING

| ITEM | THICKNESS | | END LAPS AND BUTT STRAPS | | | | | SEAMS | |
|---|---|---|---|---|---|---|---|---|---|
| | Above | Not exceeding | Diameter of rivets | Type of end lap and single butt strap | Breadth | | Spacing of rivets centre to centre | Type of seam | Breadth |
| | | | | | End laps | Butt strap | | | |
| | Millimetres | Millimetres | Millimetres | | Millimetres | Millimetres | Millimetres | | Millimetres |
| Sheerstrake for 0,4L amidships. *See* note 4.<br>Bottom Plating from keel to upper turn of bilge for 0,4L amidships.<br>Keel Plates. *See* note 4.<br>Boss Plates. | | 9 | 16 | Double | 110 | 205 | 55 | Single | 55 |
| | 9 | 10,5 | 19 | Double | 125 | 250 | 75 | Double | 115 |
| | 10,5 | 12,5 | 19 | Treble | 190 | 360 | 75 | Double | 115 |
| | 12,5 | 17,5 | 22 | Treble | 230 | 425 | 90 | Double | 135 |
| | 17,5 | 18,5 | 22 | Quadruple | 305 | 560 | 90 | Double | 135 |
| | 18,5 | 21,5 | 25 | Quadruple | 355 | 635 | 100 | Double | 150 |
| | 21,5 | 24 | 25 | Quintuple | 445 | | 115 | Double | 150 |
| | 24 | 29 | 28 | Quintuple | 510 | | 125 | Double | 170 |
| | 29 | 32 | 31 | Quintuple | 530 | | 140 | | |
| Sheerstrake at ends.<br>Bottom Plating from keel to upper turn of bilge at ends. | | 9 | 16 | Double | 110 | 205 | 55 | Single | 55 |
| | 9 | 10,5 | 19 | Double | 125 | 250 | 75 | Double | 115 |
| | 10,5 | 12,5 | 19 | Treble | 190 | 360 | 75 | Double | 115 |
| | 12,5 | 17,5 | 22 | Treble | 230 | 425 | 90 | Double | 135 |
| | 17,5 | 18,5 | 22 | Quadruple | 305 | 560 | 90 | Double | 135 |
| | 18,5 | 24 | 25 | Quadruple | 355 | 635 | 100 | Double | 150 |
| Side Plating from upper turn of bilge to sheerstrake. | | 9 | 16 | Double | 110 | 205 | 55 | Single | 55 |
| | 9 | 10,5 | 19 | Double | 125 | 250 | 75 | Single | 65 |
| | 10,5 | 12,5 | 19 | Treble | 190 | 360 | 75 | Double | 115 |
| | 12,5 | 17,5 | 22 | Treble | 230 | 425 | 90 | Double | 135 |
| | 17,5 | 18,5 | 22 | Quadruple | 305 | 560 | 90 | Double | 135 |
| | 18,5 | 21,5 | 25 | Quadruple | 355 | 635 | 100 | Double | 150 |
| | 21,5 | 24 | 25 | Quadruple | 355 | 635 | 100 | Treble | 215 |
| | 24 | 26,5 | 28 | Quadruple | 405 | 720 | 115 | Treble | 240 |

### NOTES.—TABLE 52 B

1. Treble riveted double butt straps may be fitted as an alternative to quintuple riveted end laps.

2. The number of rows of rivets in seams all fore and aft is to be regulated by the thickness of plating amidships. (Except as covered by notes 7 and 8.)

3. Seams of side plating in all ships exceeding 84 metres in length are to be not less than double riveted. (Except as covered by note 8.)

4. In seams of keel and sheerstrake the diameter of rivets and type of seam are to be regulated by the adjacent plating. (Except as covered by note 8.)

5. For number of rivets between frames in seams of shell plating *see* Table 52 E. Where the form of the ship, forward and aft, is curved the spacing of the rivets is not to exceed $4\frac{1}{2}$ diameters. (For special requirements for ships above 152,5 metres *see* note 7.) Where longitudinal framing is adopted the spacing of rivets in seams of shell plating is not to exceed $4\frac{1}{2}$ diameters, or 4 diameters in way of the strengthening of bottom forward.

6. For riveting in way of strengthening of bottom forward *see* D 808. For riveting in oil fuel bunkers *see* Table 52 H. For riveting in way of strengthening for navigation in ice *see* D 1004, D 1012, and D 1020.

7. In ships above 152,5 metres in length in the three seams nearest to the neutral axis and for one-fourth of the ship's length in the forward and after bodies the following additions are to be made :—

Above 152,5 metres and not exceeding 160 metres an additional pair of rivets is to be fitted in each frame space.
Above 160 metres and not exceeding 167,5 metres two additional pairs of rivets are to be fitted in each frame space.
Above 167,5 metres and not exceeding 183 metres one seam, and in ships exceeding 183 metres two seams, are to be treble riveted, two additional pairs of rivets being fitted in each frame space in the other seam or seams.

In all the above ships one additional pair of rivets only need be fitted in way of 685 mm. frame spacing.

8. In ships where the draught does not exceed 0,7D (D being measured to the uppermost continuous deck) and the riveting required by Table 19 for the strength deck stringer angle is single, the lower edge of the sheerstrake may also be single riveted.

9. Seams of long bridges may be single riveted where the riveting required by Table 19 is single but are to be double riveted for four frame spaces at the ends.

10. Seams of poops, short bridges and forecastles may be single riveted.

11. In single riveted seams the rivet is to pass through the frame. In double riveted seams one frame rivet (that adjacent to the caulking edge) is to pass through the seams at each frame except where the frames or edges of the plating are joggled when both rivets are to pass through the frame. In treble riveted seams two frame rivets, the upper and the lower, are to pass through the seams at each frame.

## END LAPS AND SEAMS OF DECK PLATING

| ITEM | THICKNESS | | END LAPS AND BUTT STRAPS | | | | | SEAMS | |
|---|---|---|---|---|---|---|---|---|---|
| | Above | Not exceeding | Diameter of rivets | Type of end lap and single butt strap | Breadth | | Spacing of rivets centre to centre | Type of seam | Breadth |
| | | | | | End laps | Butt strap | | | |
| | Millimetres | Millimetres | Millimetres | | Millimetres | Millimetres | Millimetres | | Millimetres |
| Strength deck stringer plates for 0,4L amidships. | | 9 | 16 | Double | 110 | 205 | 65 | See Note 2 | |
| | 9 | 10,5 | 19 | Double | 125 | 250 | 75 | | |
| | 10,5 | 12,5 | 19 | Treble | 190 | 360 | 75 | | |
| | 12,5 | 17,5 | 22 | Treble | 230 | 425 | 90 | | |
| | 17,5 | 18,5 | 22 | Quadruple | 305 | 560 | 90 | | |
| | 18,5 | 21,5 | 25 | Quadruple | 355 | 635 | 100 | | |
| | 21,5 | 24 | 25 | Quintuple | 445 | | 115 | | |
| | 24 | 29 | 28 | Quintuple | 510 | | 125 | | |
| | 29 | 32 | 31 | Quintuple | 530 | | 140 | | |
| Strength deck stringer plates at ends.<br>Lower deck stringer plates.<br>Deck tie plates. | | 9 | 16 | Double | 110 | 205 | 70 | See Note 2 | |
| | 9 | 10,5 | 19 | Double | 125 | 250 | 85 | | |
| | 10,5 | 12,5 | 19 | Treble | 190 | 360 | 85 | | |
| | 12,5 | 17,5 | 22 | Treble | 230 | 425 | 100 | | |
| | 17,5 | 18,5 | 22 | Quadruple | 305 | 560 | 100 | | |
| | 18,5 | 24 | 25 | Quadruple | 355 | 635 | 115 | | |
| | 24 | 29 | 28 | Quadruple | 405 | 720 | 125 | | |
| | 29 | 32 | 31 | Quadruple | 420 | 745 | 140 | | |
| Strength deck plating for 0,4L amidships. | | 9 | 16 | Double | 110 | 205 | 65 | Single | 55 |
| | 9 | 12 | 19 | Double | 125 | 250 | 75 | Single | 65 |
| | 12 | 12,5 | 19 | Treble | 190 | 360 | 75 | Single | 65 |
| | 12,5 | 17,5 | 22 | Treble | 230 | 425 | 90 | Single | 75 |
| | 17,5 | 18,5 | 22 | Quadruple | 305 | 560 | 90 | Single | 75 |
| | 18,5 | 19,5 | 25 | Quadruple | 355 | 635 | 100 | Single | 90 |
| | 19,5 | 24 | 25 | Quadruple | 355 | 635 | 100 | Double | 150 |
| | 24 | 29 | 28 | Quadruple | 405 | 720 | 115 | Double | 170 |
| Lower deck plating for 0,4L amidships. | | 9 | 16 | Double | 110 | 205 | 70 | Single | 55 |
| | 9 | 12 | 19 | Double | 125 | 250 | 85 | Single | 65 |
| | 12 | 12,5 | 19 | Treble | 190 | 360 | 85 | Single | 65 |
| | 12,5 | 17,5 | 22 | Treble | 230 | 425 | 100 | Single | 75 |
| Deck plating at ends. | | 9 | 16 | Single | 65 | 115 | 70 | Single | 55 |
| | 9 | 10,5 | 19 | Single | 75 | 135 | 85 | Single | 65 |
| | 10,5 | 12,5 | 19 | Double | 125 | 250 | 85 | Single | 65 |
| | 12,5 | 13,5 | 22 | Double | 150 | 285 | 100 | Single | 75 |
| | 13,5 | 17,5 | 22 | Treble | 230 | 425 | 100 | Single | 75 |

### NOTES.—TABLE 52 C

1. Treble riveted double butt straps may be fitted as an alternative to quintuple riveted end laps.

2. In seams of stringer plates the diameter of rivets and type of seam are to be regulated by the thickness of the adjacent deck plating.

3. For number of rivets between beams in seams of deck plating *see* Table 52 E. The spacing of rivets in seams not parallel with the middle line of the ship, and in seams over deep tanks and oil cargo tanks, is not to exceed $4\frac{1}{2}$ diameters. Where longitudinal framing is adopted the spacing of rivets in seams of deck plating is not to exceed $4\frac{1}{2}$ diameters.

4. Where the riveting is not otherwise required to be increased the seams and butts of deck plating over oil fuel bunkers may be single riveted if not more than 8,5 metres below the top of the overflow ; elsewhere the riveting is to be double.

5. For riveting of stringer angles on strength decks *see* Table 19. For riveting of stringer angles on lower decks *see* Table 52 F.

6. Butts of deck plating within line of openings need only be single riveted.

# TABLE 52 D

## RIVETING AND WELDING

## D

## END LAPS AND SEAMS OF DOUBLE BOTTOMS

| ITEM | THICKNESS | | END LAPS AND BUTT STRAPS | | | | | SEAMS | |
|---|---|---|---|---|---|---|---|---|---|
| | Above | Not exceeding | Diameter of rivets | Type of end lap and single butt strap | Breadth | | Spacing of rivets centre to centre | Type of seam | Breadth |
| | | | | | End laps | Butt strap | | | |
| | Millimetres | Millimetres | Millimetres | | Millimetres | Millimetres | Millimetres | | Millimetres |
| Inner bottom middle line strake.<br>Inner bottom plating for 0,4L amidships.<br>Margin plates.<br>Centre and side girders (butts). | | 9 | 16 | Double | 110 | 205 | 65 | Single | 55 |
| | 9 | 12 | 19 | Double | 125 | 250 | 75 | Single | 65 |
| | 12 | 12,5 | 19 | Treble | 190 | 360 | 75 | Double | 115 |
| | 12,5 | 17,5 | 22 | Treble | 230 | 425 | 90 | Double | 135 |
| | 17,5 | 18,5 | 22 | Quadruple | 305 | 560 | 90 | Double | 135 |
| | 18,5 | 24 | 25 | Quadruple | 355 | 635 | 100 | | |
| Inner bottom plating at ends. | | 9 | 16 | Single | 65 | 115 | 65 | Single | 55 |
| | 9 | 10,5 | 19 | Single | 75 | 135 | 75 | Single | 65 |
| | 10,5 | 12 | 19 | Double | 125 | 250 | 75 | Single | 65 |
| | 12 | 12,5 | 19 | Double | 125 | 250 | 75 | Double | 115 |
| | 12,5 | 13,5 | 22 | Double | 150 | 285 | 90 | Double | 135 |
| | 13,5 | 17,5 | 22 | Treble | 230 | 425 | 90 | Double | 135 |

**NOTES.—TABLE 52 D**

1. In seams of middle line strake of inner bottom and margin plates the diameter of rivets and type of seam are to be regulated by the thickness of the adjacent inner bottom plating.

2. Where oil fuel is carried in the double bottom and ceiling is not fitted completely over the inner bottom the seams and end laps are to be not less than double riveted.

3. For number of rivets between frames in seams of inner bottom plating *see* Table 52 E. The spacing of rivets in seams not parallel with the middle line of the ship is not to exceed 4 diameters. Where longitudinal framing is adopted the spacing of rivets in seams of inner bottom plating is not to exceed 4 diameters.

# RIVETING AND WELDING

## E

## NUMBER OF RIVETS IN SEAMS OF PLATING BETWEEN FRAMES AND BEAMS EXCLUDING RIVETS IN FRAMES AND BEAMS

| FRAME OR BEAM SPACING | THICKNESS OF SHELL AND DECK PLATING IN MILLIMETRES | | | | | | THICKNESS OF INNER BOTTOM PLATING IN MILLIMETRES | | |
|---|---|---|---|---|---|---|---|---|---|
| | Not exceeding 9 | Above 9 and not exceeding 12,5 | Above 12,5 and not exceeding 18,5 | Above 18,5 and not exceeding 24 | Above 24 and not exceeding 29 | Above 29 to 32 | Not exceeding 9 | Above 9 and not exceeding 12,5 | Above 12,5 and not exceeding 18,5 |
| | Diameter of rivet in millimetres | | | | | | Diameter of rivet in millimetres | | |
| MILLIMETRES | 16 | 19 | 22 | 25 | 28 | 32 | 16 | 19 | 22 |
| | Number of rivets in each row | | | | | | Number of rivets in each row | | |
| 510 | 6 | 5 | | | | | 7 | 6 | |
| 520 | 7 | 5 | | | | | 7 | 6 | |
| 535 | 7 | 5 | 5 | | | | 7 | 6 | 5 |
| 545 | 7 | 6 | 5 | | | | 7 | 6 | 5 |
| 560 | 7 | 6 | 5 | | | | 8 | 6 | 5 |
| 570 | 7 | 6 | 5 | | | | 8 | 6 | 5 |
| 585 | 7 | 6 | 5 | 5 | | | 8 | 7 | 6 |
| 595 | | 6 | 5 | 5 | | | 8 | 7 | 6 |
| 610 | | 6 | 5 | 5 | | | 8 | 7 | 6 |
| 620 | | 6 | 5 | 5 | | | 9 | 7 | 6 |
| 635 | | 7 | 6 | 5 | | | 9 | 7 | 6 |
| 645 | | 7 | 6 | 5 | | | | 7 | 7 |
| 660 | | 7 | 6 | 5 | 5 | | | 8 | 7 |
| 675 | | 7 | 6 | 5 | 5 | | | 8 | 7 |
| 685 | | 7 | 6 | 5 | 5 | | | 8 | 7 |
| 695 | | 7 | 6 | 5 | 5 | | | 8 | 7 |
| 710 | | 7 | 6 | 5 | 5 | 5 | | 8 | 7 |
| 725 | | 8 | 6 | 6 | 5 | 5 | | 8 | 7 |
| 735 | | 8 | 7 | 6 | 5 | 5 | | | 8 |
| 750 | | 8 | 7 | 6 | 5 | 5 | | | 8 |
| 760 | | 8 | 7 | 6 | 5 | 5 | | | 8 |
| 775 | | 8 | 7 | 6 | 5 | 5 | | | 8 |
| 785 | | 9 | 7 | 6 | 5 | 5 | | | 8 |
| 800 | | | 7 | 6 | 6 | 5 | | | 8 |
| 815 | | | 7 | 6 | 6 | 5 | | | 8 |
| 825 | | | 7 | 6 | 6 | 5 | | | 8 |
| 840 | | | 8 | 7 | 6 | 5 | | | 9 |
| 850 | | | 8 | 7 | 6 | 5 | | | 9 |
| 865 | | | 8 | 7 | 6 | 6 | | | 9 |
| 875 | | | 8 | 7 | 6 | 6 | | | 9 |
| 890 | | | 8 | 7 | 6 | 6 | | | 9 |
| 900 | | | 8 | 7 | 6 | 6 | | | 9 |
| 915 | | | 8 | 7 | 6 | 6 | | | 9 |

## F

NUMBER OF RIVETS BETWEEN FRAMES IN EACH FLANGE OF THE ANGLES CONNECTING STRINGER PLATES TO SHELL AND INTERCOSTAL GIRDERS TO SHELL AND INNER BOTTOM

| FRAME SPACING MILLIMETRES | | DIAMETER OF RIVET IN MILLIMETRES | | | |
|---|---|---|---|---|---|
| | | 16 | 19 | 22 | 25 |
| Above | Not exceeding | NUMBER OF RIVETS | | | |
| — | 610 | 5 | 4 | 4 | |
| 610 | 685 | 6 | 5 | 5 | 4 |
| 685 | 760 | 7 | 6 | 5 | 5 |
| 760 | 840 | | 7 | 6 | 5 |
| 840 | 915 | | | 7 | 6 |

For strength deck stringer angles *see* Table 19.

TABLE 52 G

# RIVETING AND WELDING

## G

## TYPES OF WELDING

### SIZE OF FILLET WELDS

| PLATING THICKNESS | BASIC THROAT THICKNESS |
|---|---|
| mm. | mm. |
| 6,0 | 4,0 |
| 7,5 | 4,5 |
| 9,0 | 5,0 |
| 10,5 | 5,5 |
| 12,0 | 6,0 |
| 14,0 | 6,5 |
| 16,0 | 7,0 |
| 18,0 | 8,0 |
| 20,5 | 9,0 |
| 23,0 | 10,0 |
| 25,5 | 11,0 |

**NOTES.—TABLE 52 G**

1. **Basic throat thickness** is to be governed by the thickness of the abutting plate or web. Where the difference between the thickness of the parts to be joined is considerable the size of fillet will be specially considered.

2. **Basic throat thickness** for intermediate thickness to be obtained by direct interpolation.

3. **Throat thickness for double continuous fillets** is the product of Basic Throat Thickness and the Weld Factor required by Table 52 H.

4. **Throat thickness for intermittent fillets** is to be given by the formula

Throat thickness = Basic Throat Thickness × Weld Factor × $\frac{d}{s}$ where s and d are as defined in the sketches below. The length s should not be less than 75 mm. and s and d are to be such that the required throat thickness does not exceed the Basic Throat Thickness.

5. **Minimum throat thickness** of fillet weld to be 0,65 of the Basic Throat Thickness except where a reduction is allowed for flat bar longitudinals. **In no case is the throat thickness to be less than 3,5 mm.**

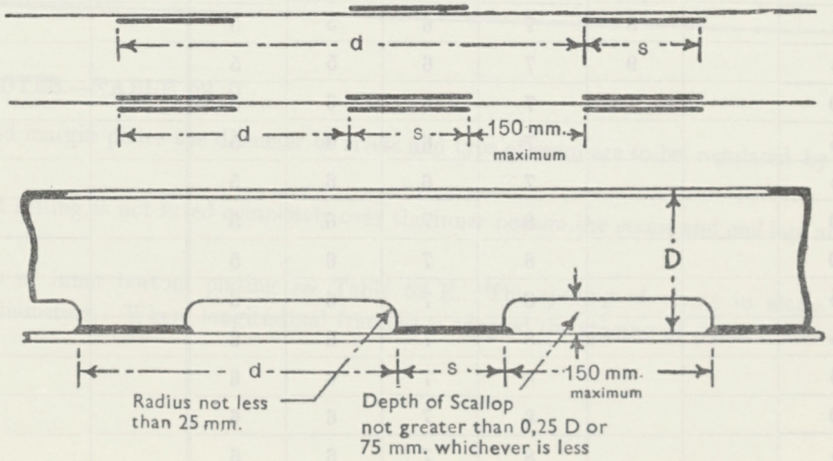
6. **Leg length** of welds is to be 140 per cent of the throat thickness.

STAGGERED INTERMITTENT
To be doubled at ends. *See* D 3117

CHAIN INTERMITTENT

SCALLOPED FRAMES, LONGITUDINALS, STIFFENERS, etc., WITH DOUBLE FILLET WELDS

Welding to be carried round the ends of all lugs
*See also* D 3117.



# TABLE 52 H
(SEE CONTINUATION)

## DETAILS OF VARIOUS STRUCTURAL CONNECTIONS

The breadths of flanges of connecting angles are generally to be not less than four times the rivet diameter for rivets up to 22 mm. in diameter and three and a half times for rivets 25 mm. and above in diameter.

The distance from the centre of the rivet hole to the edge of the angle is to be not less than one and a half rivet diameters.

| ITEM | RIVETED | WELDED | |
|---|---|---|---|
| | MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS | WELD FACTOR | NOTES |
| **TRANSVERSE FRAMING** | | | |
| Hold frames to shell: Spacing not over 740 mm. | 7 | 0,21 | |
| Hold frames to shell: ,, over 740 mm. and up to 810 mm. | 6½ | 0,23 | |
| Hold frames to shell: ,, ,, 810 ,, ,, ,, 860 ,, | 6 | 0,25 | |
| Hold frames to shell: ,, ,, 860 ,, | 5½ | 0,27 | |
| Hold frames to shell: in deep, oil fuel and peak tanks and in panting region (D 9) | 5½ | 0,27 | |
| Reversed frames to frames | 7 | | |
| Frames to tank side brackets—spacing not to exceed 7 diameters | See Table 11 | | |
| 'Tween deck frames to shell | 7 | 0,21 | |
| Intermediate frames to shell (D 1004, D 1012 and D 1020) | 7 | 0,21 | |
| Bottom frames to shell and floors or floor plates to shell: Spacing not over 810 mm. | 7 | 0,21 | |
| Bottom frames to shell and floors or floor plates to shell: ,, over 810 mm. and up to 860 mm. | 6½ | 0,23 | |
| Bottom frames to shell and floors or floor plates to shell: ,, ,, 860 ,, | 6 | 0,25 | no scallops in way of keel |
| Bottom frames to shell and floors or floor plates to shell: in the forward 0,25L | 5½ | 0,27 in Peaks<br>0,54 elsewhere | no scallops in way of keel |
| Floors and cross ties to frames in fore peak | 6 | 0,25 | |
| ,, ,, ,, ,, aft ,, | 5 | 0,30 | |
| **LONGITUDINAL FRAMING** | | | |
| Bottom frames to shell and floors, or floor plates to shell (*see also* D 519) | 5 | 0,30<br>0,60 | no scallops at ends |
| Bottom longitudinals to shell in the forward 0,25L | 5½ | 0,27 | |
| ,, ,, ,, ,, remainder | 6 | 0,25 | |
| Bottom longitudinals of flatbar type to shell | | | continuous weld—throat thickness 21 per cent of thickness of the thinner member being connected |
| **DOUBLE BOTTOMS (Transversely framed)** | | | |
| Centre girder to keel | 5 S.R. | 0,80 | if watertight |
| ,, ,, ,, | 6½ D.R. | 0,60 | elsewhere |
| ,, ,, inner bottom (except in way of centre line bulkhead) | 7 | 0,80<br>0,50 | if watertight<br>in engine space and under thrust — no scallops |
| Centre girder to inner bottom (in way of centre line bulkhead) | 5 | 0,43 | elsewhere — no scallops |
| Floors to centre girder | 5 | 0,60<br>0,30 | under engine, thrust and boiler bearers<br>elsewhere |
| Floors to intercostal side girders | 7 | 0,21 | |
| Intercostal side girder to shell | See Table 52 F | 0,25 | |
| ,, ,, ,, inner bottom under engine and thrust | See Table 52 F | 0,50 | |
| ,, ,, ,, ,, ,, elsewhere | See Table 52 F | 0,21 | |
| Reversed frames to floors and inner bottom or floor plates to inner bottom | 6 D.R.<br>7 S.R. | 0,50<br>0,21 | under engine and thrust<br>elsewhere |
| (For bottom frames to shell and floors or floor plates to shell *see* Transverse framing above) | | | |
| Margin plate to shell | 4½ | 0,80 | |
| Margin connection to tank side brackets and floors | See Table 11 | to depend on design | generally 1,00 in panting, 0,80 elsewhere |
| Boundaries of watertight and oiltight floors | 5 | 1,00 | |
| Stiffeners ,, ,, ,, | 5 | 0,30 | |
| Riveting and welding in way of heavy oil engines—To be specially considered. | | | |

TABLE 52 H
(SEE CONTINUATION)

# RIVETING AND WELDING
## H
## DETAILS OF VARIOUS STRUCTURAL CONNECTIONS

| ITEM | RIVETED | WELDED | |
|---|---|---|---|
| | MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS | WELD FACTOR | NOTES |
| **DOUBLE BOTTOMS (Longitudinally framed)** | | | |
| Longitudinals to inner bottom | 6 | 0,25 | |
| Bracket floors and longitudinal framing | See Table 8 | | |
| Floors to centre girder (*see also* D 519) | 5 | 0,60 | no scallops |
| ,, ,, ,, when spacing of floors exceeds 2,45 metres (*see also* D 519) | 5 | 1,00 | |
| Reversed frames to floors and inner bottom or floor plates to inner bottom (*see also* D 519) | 5 | 0,30<br>0,60 | for 2 spaces at ends with one scallop per space |
| **SINGLE BOTTOMS** | | | |
| Centre keelson to keel | 5 | 0,60 | no scallops |
| Reversed frames or face plates to floors | 7 | 0,21 | |
| (For bottom frames to shell and floors or floor plates to shell *see* Transverse framing) | | | |
| Floors to centre keelson (double riveted connection where floors cut) | 4 | 1,00 | |
| Foundation plates to reversed frames | 4 | | |
| Continuous keelson top angles or face plates to vertical keelson plates | 7 | 0,21 | maximum—one scallop per frame space |
| Butts of keelsons and foundation plates | 4 | | |
| Connection of reversed frames to side keelsons—not less than 2 rivets. | | | |
| Side keelsons to shell | See Table 52 F | 0,25 | maximum—one scallop per frame space |
| Riveting or welding in way of machinery—to be specially considered. | | | |
| **WATERTIGHT BULKHEADS, FLATS AND TUNNELS** | | | |
| Horizontal connections of plating may be single riveted. | | | |
| Vertical connections of plating and boundary angles are to be double riveted when more than 10,7 metres below the top of the bulkhead. | | | |
| Overlaps of plating | 4½ | | |
| Boundary connections to shell, inner bottom and decks | 5 | 0,80 | |
| ,, ,, ,, bulkhead | 4½ | 0,80 | |
| Stiffeners (except as below) | 7 | 0,21 | |
| Stiffeners, lugged or unattached, for 15 per cent of length at each end | 4 | 0,38 | |
| Brackets and lugs | See Table 36 | | |
| **BULKHEADS OF DEEP TANKS, PEAK TANKS AND OIL CARGO TANKS** | | | |
| Overlaps of plating and boundary angles to be single or double riveted as for watertight bulkheads. | | | |
| Overlaps of plating | 4 | | |
| Stiffeners, bracketed | 6 | 0,25 | |
| Boundary connections | As for W.T. bulkheads | 1,00<br>0,80 | at bottom and bilge<br>at deck and side |
| Brackets | See Table 36 | | |

# TABLE 52H
(SEE CONTINUATION)

## DETAILS OF VARIOUS STRUCTURAL CONNECTIONS

| ITEM | RIVETED | WELDED | |
|---|---|---|---|
| | MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS | WELD FACTOR | NOTES |
| **OIL FUEL BUNKERS** | | | |
| Where not otherwise required to be increased, the overlaps of plating of bulkheads, shell and deck and the stringer angle may be single riveted if not more than 8,5 metres below the top of the overflow or 4,9 metres below the top of the tank; elsewhere the riveting is to be double. | | | |
| Centre line bulkheads may be single riveted throughout. | | | |
| Overlaps of bulkhead, inner bottom and deck plating ... ... | 4 | | |
| Deck stringer connection ... ... ... ... ... ... | 4 | 0,80 | except at strength deck |
| Boundary connections ... ... ... ... ... ... | 5 D.R. | 1,00<br>0,80 | at bottom and bilge<br>at deck and side |
| Stiffeners bracketed ... ... ... ... ... ... | 6 | 0,25 | |
| Horizontal girders to shell and bulkheads (*see also* D 2006 to D 2010) ... | 4½ | 0,33<br>0,65 | clear of brackets<br>at brackets |
| Horizontal girders—brackets ... ... ... ... ... | 4½ D.R. | 0,65 | if overlapped |
| ,, ,, —face angles or plates where area is less than 39 sq.cms ... ... ... ... ... ... ... | 7 | 0,21 | |
| Horizontal girders—face angles or plates where area is more than 39 sq.cms ... ... ... ... ... ... ... | 6 | 0,25 | |
| Stiffener brackets ... ... ... ... ... ... ... | See Table 36 | | |
| **NON-WATERTIGHT BULKHEADS** | | | |
| Overlaps of plating... ... ... ... ... ... ... | 6 | | |
| Boundary connections to inner bottom, horizontal riveted flange (*see also* D 1802) ... ... ... ... ... ... | 5 | 0,30 | no scallops |
| Boundary connections elsewhere ... ... ... ... ... | 7 | 0,21 | |
| Stiffeners ... ... ... ... ... ... ... ... | 7 | 0,21 | |
| **DECKS** | | | |
| Stringer angle on strength decks ... ... ... ... ... | See Table 19 | | |
| ,, ,, lower ,, ... ... ... ... ... | ,, ,, 52 F | | |
| **BEAMS AND DECK LONGITUDINALS** | | | |
| Beams to deck ... ... ... ... ... ... ... | 7 | 0,21 | |
| ,, at crown of deep tanks, peak tanks and oil fuel tanks | 6 | 0,25 | |
| Strong beams at ends of hatchways, deck connections (*see also* Deck girders) ... ... ... ... ... ... ... | 5 | 0,30 | |
| Half beams to hatch coamings and casings—lugs of same thickness as coaming with 2 rivets or 6,5 sq.cms of welding in each flange for beams not exceeding 200 mm. and 3 rivets or 9,7 sq.cms of welding for beams exceeding 200 mm. in depth. | | | |
| Longitudinals to deck ... ... ... ... ... ... | 6 | 0,25 | |
| Deck longitudinals of flatbar type to deck plating ... ... | | 0,25 | In way of tanks, continuous weld—throat thickness 21 per cent of thickness of the thinner member being connected. |
| Beam knees ... ... ... ... ... ... ... ... | See Table 28 | | |
| **DECK GIRDERS, TRANSVERSES AND WEBS** | | | |
| Connections to plating (*see also* D 1505 to D 1508) ... ... | 5 | 0,30 | |
| Face section, not exceeding 39 sq.cms area, to web ... ... | 7 | 0,21 | |
| ,, ,, exceeding 39 sq.cms area, to web... ... ... | 6 | 0,25 | |
| End brackets ... ... ... ... ... ... ... | 5 D.R. | 0,80 | |
| Butts of girders ... ... ... ... ... ... ... | 4 | | |

TABLE 52 H
(CONCLUDED)

# RIVETING AND WELDING

## H

## DETAILS OF VARIOUS STRUCTURAL CONNECTIONS

| ITEM | RIVETED | WELDED | |
|---|---|---|---|
| | MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS | WELD FACTOR | NOTES |
| **PILLARS** | | | |
| Heads and heels of solid pillars ... ... ... ... ... | See Table 31 | | |
| Seams of tubular pillars ... ... ... ... ... ... | 5 | | |
| Riveting or welding of pillars built of rolled sections ... ... | 7 | 0,21 | |
| End connections of widely spaced built pillars ... ... ... | 5 | 0,80 | |
| **HATCHWAYS** | | | |
| Coaming to deck ... ... ... ... ... ... ... | 5 | 0,80 | |
| ,, ,, at corners ... ... ... ... ... | $4\frac{1}{2}$ | 1,00 | |
| Stiffener to coaming ... ... ... ... ... ... | 7 | 0,21 | |
| Horizontal stiffeners on coaming where forming watertight recess ... ... ... ... ... ... ... ... | 5 | 0,80 | |
| Hatch beam angles or face plates ... ... ... ... | 7 | 0,21 | |
| Vertical corner angles ... ... ... ... ... ... | 5 | | |
| **VENTILATORS** | | | |
| Connection to deck (*see also* D 2403) ... ... ... ... | 4 | 0,80 | |
| **DECKHOUSES** | | | |
| Overlaps of outer casings ... ... ... ... ... ... | 5 | | |
| ,, inner ,, ... ... ... ... ... ... | 6 | | |
| Foundation connections (*see also* D 1209 and D 1210) ... ... | 5 | 0,80 | |
| Stiffeners ... ... ... ... ... ... ... ... ... | 7 | 0,21 | |
| **MASTS** | | | |
| End laps are to be treble riveted and seams single riveted. Overlaps of plating ... ... ... ... ... ... ... ... | 5 | | |
| **RUDDERS** | | | |
| Spacing of rivets in arms (*see also* D 2618) ... ... ... | $4\frac{1}{2}$ | | |
| **STEMS AND STERNFRAMES** | | | |
| Connections to shell plating: diameter of rivet with solid sections to be 6 mm. greater than required for the thickness of the plating and 3 mm. greater for castings or built frames but not to exceed 28 mm. ... ... ... ... ... | 5 | | |
| In ships above 107 metres in length shell plating is to be connected to sternframe below the boss by three rows of rivets. | | | |
| Connection to transom plate: for ships not exceeding 91,5 metres in length by two single riveted angles, in ships above 91,5 metres in length by two double riveted angles ... ... | 5 | | |

# TABLE 53

(SEE CONTINUATION)

## EQUIPMENT

| Equipment Number (*See* D 3303 and D4017) | Equipt. Letter | Stockless Bower Anchors | | Stocked Stream Anchor | Stud Link Chain Cable | | | Stream Wire or Short Link Chain | | Towline | | Mooring Ropes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Minimum Diameter | | | | | | | | |
| | | Number | Weight Per Anchor | Weight Ex Stock | Length | Wrought Iron or Mild Steel | Special Steel (*see notes*) | Length | Breaking Strength Wire or Chain | Length | Breaking Strength Wire or Fibre (*d*) | Number | Length of Each | Breaking Strength Wire or Fibre (*e*) |
| | | | Kg. | Kg. | Metres | mm. | mm. | Metres | Kg. | Metres | Kg. | | Metres | Kg. |
| **280** | a | 2 | 225 | 40 | 220 | 17,5 | | 80 | 8130 | 130 | 7820 | 2 | 130 | 3560 |
| **335** | b | 2 | 270 | 65 | 220 | 19 | | 80 | 9240 | 130 | 8670 | 2 | 130 | 3610 |
| **390** | c | 2 | 315 | 90 | 250 | 20,5 | | 90 | 10360 | 145 | 9550 | 2 | 145 | 3660 |
| **445** | d | 2 | 360 | 115 | 275 | 22 | | 90 | (*a*) 11480 | 145 | 10470 | 2 | 145 | 3760 |
| **500** | e | 2 | 405 | 140 | 275 | 24 | | 90 | 12600 | 145 | 11440 | 2 | 165 | 3920 |
| **555** | f | 2 | 450 | 165 | 300 | 25,5 | | 90 | 13720 | 145 | 12450 | 2 | 165 | 4170 |
| **620** | g | 3 | 495 | | 330 | 27 | 24 | | | 145 | 13490 | 2 | 165 | 4580 |
| **685** | h | 3 | 600 | | 355 | 28,5 | 25,5 | | | 145 | 14580 | 2 | 165 | 5180 |
| **750** | i | 3 | 705 | | 355 | 30 | 27 | | | 165 | 15710 | 2 | 165 | 6100 |
| **825** | j | 3 | 810 | | 385 | 32 | 27 | | | 165 | 16890 | 2 | 165 | 7090 |
| **900** | k | 3 | 920 | | 385 | 33,5 | 28,5 | | | 165 | 18140 | 3 | 165 | 5385 |
| **985** | l | 3 | 1030 | | 385 | 35 | 30 | | | 165 | 19490 | 3 | 165 | 6130 |
| **1075** | m | 3 | 1140 | | 385 | 36,5 | 31,5 | | | 165 | (*a*) 20980 | 3 | 165 | 7080 |
| **1180** | n | 3 | 1250 | | 385 | 38 | 33 | | | 165 | 22660 | 3 | 165 | 8080 |
| **1290** | o | 3 | 1360 | | 440 | 39,5 | 35 | | | 185 | 24560 | 3 | 165 | 9140 |
| **1410** | p | 3 | 1480 | | 440 | 41,5 | 36,5 | | | 185 | 26720 | 3 | 165 | 10270 |
| **1550** | q | 3 | 1600 | | 440 | 43 | 36,5 | | | 185 | 29190 | 3 | 185 | (*a*) 11480 |
| **1720** | r | 3 | 1720 | | 440 | 44,5 | 38 | | | 185 | 32000 | 3 | 185 | 12750 |
| **1915** | s | 3 | 1870 | | 440 | 46 | 39,5 | | | 185 | 35110 | 3 | 185 | 14040 |
| **2110** | t | 3 | 2025 | | 440 | 47,5 | 41 | | | 185 | 38470 | 3 | 185 | 15330 |
| **2320** | u | 3 | 2195 | | 495 | 49 | 42,5 | | | 200 | 42010 | 3 | 185 | 16620 |
| **2535** | v | 3 | 2365 | | 495 | 51 | 44,5 | | | 200 | 45700 | 4 | 185 | 13465 |
| **2760** | w | 3 | 2540 | | 495 | 52,5 | 46 | | | 200 | 49490 | 4 | 185 | 14475 |
| **2990** | x | 3 | 2730 | | 495 | 54 | 46 | | | 200 | 53450 | 4 | 185 | 15515 |
| **3235** | y | 3 | 2920 | | 495 | 55,5 | 47,5 | | | 200 | 57570 | 4 | 185 | 16585 |
| **3495** | z | 3 | 3120 | | 495 | 57 | 49 | | | 200 | 61810 | 4 | 185 | 17685 |
| **3755** | a† | 3 | 3320 | | 495 | 58,5 | 50,5 | | | 220 | 66170 | 4 | 185 | 18815 |
| **4015** | b† | 3 | 3520 | | 550 | 60,5 | 52,5 | | | 220 | 70620 | 4 | 185 | 19975 |
| **4275** | c† | 3 | 3730 | | 550 | 62 | 54 | | | 220 | 75150 | 4 | 200 | 21165 |
| **4535** | d† | 3 | 3940 | | 550 | 63,5 | 55,5 | | | 220 | 79760 | 4 | 200 | 22395 |
| **4795** | e† | 3 | 4155 | | 550 | 65 | 57 | | | 220 | 84410 | 4 | 200 | 23655 |
| **5070** | f† | 3 | 4370 | | 550 | 66,5 | 57 | | | 220 | 89130 | 5 | 200 | 19950 |
| **5350** | g† | 3 | 4585 | | 605 | 68 | 58,5 | | | 240 | (*b*) 93890 | 5 | 200 | 21050 |
| **5630** | h† | 3 | 4800 | | 605 | 69,5 | 60 | | | 240 | 98670 | 5 | 200 | 22155 |
| **5925** | i† | 3 | 5020 | | 605 | 71,5 | 62 | | | 240 | 103490 | 5 | 200 | 23265 |
| **6225** | j† | 3 | 5240 | | 605 | 73 | 63,5 | | | 240 | 108360 | 5 | 200 | 24385 |
| **6520** | k† | 3 | 5475 | | 605 | 74,5 | 65 | | | 240 | 113300 | 5 | 200 | 25515 |
| **6820** | l† | 3 | 5690 | | 605 | 76 | 66,5 | | | 240 | 118380 | 5 | 200 | 26655 |
| **7135** | m† | 3 | 5905 | | 605 | 78 | 68,5 | | | 255 | 123670 | 5 | 200 | 27805 |
| **7450** | n† | 3 | 6120 | | 605 | 79,5 | 70 | | | 255 | 129190 | 5 | 200 | 28965 |
| **7785** | o† | 3 | 6350 | | 605 | 81 | 70 | | | 255 | 134600 | 5 | 220 | 30135 |
| **8140** | p† | 3 | 6590 | | 605 | 82,5 | 71,5 | | | 255 | 140000 | 5 | 220 | 31315 |
| **8510** | q† | 3 | 6845 | | 605 | 84 | 73 | | | 255 | 145400 | 6 | 220 | (*b*) 27115 |
| **8900** | r† | 3 | 7110 | | 605 | 86 | 74,5 | | | 255 | 150800 | 6 | 220 | 28110 |
| **9310** | s† | 3 | 7390 | | 605 | 87,5 | 76 | | | 275 | 156200 | 6 | 220 | 29140 |
| **9755** | t† | 3 | 7695 | | 605 | 89 | 77,5 | | | 275 | (*c*) 161500 | 6 | 220 | 30180 |
| **10225** | u† | 3 | 8000 | | 605 | 90,5 | 79,5 | | | 275 | 166700 | 6 | 220 | 31220 |
| **10690** | v† | 3 | 8305 | | 605 | 92 | 81 | | | 275 | 171200 | 6 | 220 | 32260 |
| **11155** | w† | 3 | 8610 | | 605 | 93,5 | 82,5 | | | 275 | 175000 | 6 | 220 | 33300 |
| **11619** | x† | 3 | 8915 | | 605 | 95 | 84 | | | 275 | 178800 | 6 | 220 | 34340 |
| **12085** | y† | 3 | 9220 | | 605 | 97 | 85,5 | | | 275 | 182000 | 6 | 220 | 35380 |
| **12550** | z† | 3 | 9550 | | 605 | 98,5 | 87,5 | | | 275 | 185000 | 6 | 220 | 36420 |

(*a*) = 6 × 12 Flexible Steel Wire Rope. (*b*) = 6 × 24 Flexible Steel Wire Rope. (*c*) = 6 × 37 Flexible Steel Wire Rope.
(*d*) = 3 Strand Fibre Rope. (*e*) = 4 Strand Fibre Rope.

| Equipment Number (*See* D 3303 and D4017) | Equipt. Letter | Stockless Bower Anchors | | Stocked Stream Anchor | Stud Link Chain Cable | | | Stream Wire or Short Link Chain | | Towline | | Mooring Ropes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Length | Minimum Diameter | | Length | Breaking Strength Wire or Chain | Length | Breaking Strength Wire or Fibre (*d*) | Number | Length of Each | Breaking Strength Wire or Fibre (*e*) |
| | | Number | Weight Per Anchor | Weight Ex Stock | | Wrought Iron or Mild Steel | Special Steel (*see notes*) | | | | | | | |
| | | | Kg. | Kg. | Metres | mm. | mm. | Metres | Kg. | Metres | Kg. | | Metres | Kg. |
| **13005** | a* | 3 | 9880 | | 660 | 100 | 89 | | | 290 | ∧ 188000 | 6 | 220 | ∧ 37450 |
| **13470** | b* | 3 | 10210 | | 660 | 101,5 | 90,5 | | | 290 | \| 191000 | 6 | 220 | \| 38450 |
| **13935** | c* | 3 | 10540 | | 660 | 103 | 92 | | | 290 | \| 193500 | 6 | 220 | \| 39450 |
| **14400** | d* | 3 | 10870 | | 660 | 105 | 93,5 | | | 290 | \| 196000 | 6 | 220 | \| 40450 |
| **14865** | e* | 3 | 11200 | | 660 | | 93,5 | | | 290 | \| 198500 | 7 | 220 | \| 37100 |
| **15330** | f* | 3 | 11530 | | 660 | | 95,5 | | | 290 | \| 201000 | 7 | 220 | \| 38100 |
| **15795** | g* | 3 | 11860 | | 660 | | 97 | | | 290 | \| 203500 | 7 | 220 | \| 39000 |
| **16260** | h* | 3 | 12190 | | 660 | | 98,5 | | | 290 | \| 206000 | 7 | 220 | \| 39850 |
| **16725** | i* | 3 | 12520 | | 660 | | 100 | | | 290 | (*c*) 208000 | 7 | 220 | (*b*) 40750 |
| **17185** | j* | 3 | 12850 | | 660 | | 101,5 | | | 290 | \| 210000 | 7 | 220 | \| 41600 |
| **17650** | k* | 3 | 13185 | | 660 | | 103 | | | 310 | \| 212000 | 7 | 220 | \| 42500 |
| **18115** | l* | 3 | 13515 | | 660 | | 105 | | | 310 | \| 214000 | 7 | 220 | \| 43350 |
| **18580** | m* | 3 | 13845 | | 660 | | 106,5 | | | 310 | \| 216500 | 7 | 220 | \| 44250 |
| **19045** | n* | 3 | 14175 | | 660 | | 108 | | | 310 | \| 218500 | 7 | 220 | \| 45100 |
| **19510** | o* | 3 | 14505 | | 660 | | 109,5 | | | 310 | \| 220500 | 7 | 220 | \| 45900 |
| **19975** | p* | 3 | 14835 | | 660 | | 111 | | | 310 | \| 222500 | 7 | 220 | \| 46750 |
| **20440** | q* | 3 | 15165 | | 660 | | 112,5 | | | 310 | ∨ 224500 | 7 | 220 | ∨ 47700 |

(*a*) = 6 × 12 Flexible Steel Wire Rope. (*b*) = 6 × 24 Flexible Steel Wire Rope. (*c*) = 6 × 37 Flexible Steel Wire Rope.
(*d*) = 3 Strand Fibre Rope. (*e*) = 4 Strand Fibre Rope.

## NOTES.—TABLE 53

1. Where the Equipment Number lies between any two consecutive numbers given in the Table, the equipment is to be governed by the greater.

2. Bower Anchors. The weight per anchor given in the Table is for anchors of equal weight. The weight of individual anchors may vary ± 7 per cent from the Table weight provided the total weight of anchors is not less than would have been required for anchors of equal weight.

3. If it is desired to use stocked bower anchors the weight "ex stock" is to be 80 per cent of the Table weight. For weight of stock *see* D 3304.

4. For special steel cable, *see* P 1301.

5. The weight of each 30 metre length of cable, including one joining shackle, is not to be less than that given in P1310 Tables 3A and 3B.

6. Steel wire ropes other than those given in the Table may be used if of equivalent strength.

7. Ropes of strength equivalent to the fibre 3-strand and fibre 4-strand for towline and mooring ropes may be used.

Ropes of synthetic materials will be accepted on the basis of equivalent breaking loads.

8. Tests. *See* P 1104 for anchors.
P 1309 to P 1311 for cables.
P 1405 to P 1409 for wire ropes.
P 1416 to P 1419 for fibre ropes.

# TABLE 54

## EQUIPMENT FOR TUGS

| EQUIPMENT NUMBER | STOCKLESS BOWER ANCHORS | | WROUGHT IRON OR MILD STEEL STUD LINK CHAIN CABLE | | FIBRE MOORING ROPES (4-strand) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Length of each | Breaking Strength | |
| | Number | Minimum weight of each anchor | Length | Diameter | | First | Second |
| | | Kg. | Metres | mm. | Metres | Kg. | Kg. |
| **135** | 2 | 165 | 110 | 16 | 110 | 6800 | 2500 |
| **160** | 2 | 180 | 110 | 17,5 | 110 | 7400 | 2500 |
| **185** | 2 | 190 | 110 | 17,5 | 110 | 8000 | 2500 |
| **210** | 2 | 205 | 110 | 19 | 110 | 8600 | 2500 |
| **235** | 2 | 215 | 110 | 20,5 | 110 | 9100 | 3200 |
| **260** | 2 | 230 | 135 | 20,5 | 110 | 9700 | 3800 |
| **285** | 2 | 240 | 135 | 22 | 110 | 10200 | 4500 |
| **310** | 2 | 255 | 135 | 22 | 110 | 10800 | 5200 |
| **335** | 2 | 275 | 135 | 23,5 | 110 | 11300 | 5800 |
| **365** | 2 | 290 | 165 | 23,5 | 110 | 11800 | 6400 |
| **390** | 2 | 310 | 165 | 25 | 110 | 12300 | 7100 |
| **415** | 2 | 325 | 165 | 25 | 110 | 12800 | 7800 |
| **445** | 2 | 345 | 190 | 27 | 110 | 13300 | 8400 |
| **470** | 2 | 355 | 190 | 27 | 110 | 13800 | 9100 |
| **500** | 2 | 375 | 190 | 28,5 | 110 | 14300 | 9700 |
| **530** | 2 | 385 | 220 | 28,5 | 110 | 14800 | 10300 |
| **560** | 2 | 405 | 220 | 28,5 | 110 | 15200 | 11000 |
| **585** | 2 | 425 | 245 | 30 | 110 | 15600 | 11000 |
| **615** | 2 | 445 | 245 | 30 | 110 | 16100 | 11000 |
| **645** | 2 | 470 | 245 | 30 | 110 | 16500 | 11000 |
| **675** | 2 | 495 | 275 | 31,5 | 110 | 16900 | 11000 |
| **705** | 2 | 520 | 275 | 31,5 | 110 | 17300 | 11000 |
| **735** | 2 | 545 | 275 | 31,5 | 110 | 17700 | 11000 |
| **770** | 2 | 580 | 300 | 33 | 110 | 17700 | 11000 |
| **800** | 3 | 610 | 300 | 33 | 110 | 17700 | 11000 |
| **830** | 3 | 650 | 330 | 33 | 110 | 17700 | 11000 |
| **865** | 3 | 685 | 330 | 33 | 110 | 17700 | 11000 |
| **895** | 3 | 745 | 330 | 35 | 110 | 17700 | 11000 |
| **930** | 3 | 800 | 355 | 35 | 110 | 17700 | 11000 |
| **960** | 3 | 860 | 355 | 35 | 165 | 17700 | 11000 |
| **995** | 3 | 920 | 385 | 35 | 165 | 17700 | 11000 |
| **1025** | 3 | 990 | 385 | 36,5 | 165 | 17700 | 11000 |

### NOTES.—TABLE 54

1. Where the Equipment Number lies between any two consecutive numbers given in the Table the equipment is to be governed by the greater.

2. If it is desired to use stocked anchors the weight "ex stock" is to be 80 per cent of the Table weight. For weight of stock *see* D 3304.

3. If it is desired to use short link chain the diameter is to be that for which the same proof test is required as for the stud link chain given in the Table. *See* P 1310 Table 4.

4. Tests. *See* P 1104 for anchors.
P 1309 to P 1311 for cables.
P 1405 to P 1409 for wire ropes.
P 1416 to P 1419 for fibre ropes.

# RENEWAL OF STEERING CHAINS & CHAIN CABLES WHEN WORN

When any length of a chain is so worn that the mean diameter at its most worn part is reduced to the size given in the following Table it is to be renewed.

| ORIGINAL DIAMETER | MEAN DIAMETER REQUIRING RENEWAL | ORIGINAL DIAMETER | MEAN DIAMETER REQUIRING RENEWAL | ORIGINAL DIAMETER | MEAN DIAMETER REQUIRING RENEWAL | ORIGINAL DIAMETER | MEAN DIAMETER REQUIRING RENEWAL |
|---|---|---|---|---|---|---|---|
| mm. | mm. | mm. | mm. | mm. | mm. | mm. | mm. |
| 16 | 14,5 | 35 | 31 | 54 | 48,5 | 73 | 65 |
| 17 | 15,5 | 36 | 32 | 55 | 49,5 | 74 | 66 |
| 18 | 16 | 37 | 33 | 56 | 50 | 75 | 67 |
| 19 | 17 | 38 | 34 | 57 | 51 | 76 | 68 |
| 20 | 18 | 39 | 35 | 58 | 51,5 | 77 | 69 |
| 21 | 18,5 | 40 | 36 | 59 | 52,5 | 78 | 70 |
| 22 | 19,5 | 41 | 36,5 | 60 | 53,5 | 79 | 71 |
| 23 | 20,5 | 42 | 37,5 | 61 | 54,5 | 80 | 72 |
| 24 | 21,5 | 43 | 38,5 | 62 | 55,5 | 81 | 73 |
| 25 | 22,5 | 44 | 39,5 | 63 | 56,5 | 82 | 74 |
| 26 | 23 | 45 | 40 | 64 | 57,5 | 83 | 75 |
| 27 | 24 | 46 | 41 | 65 | 58 | 84 | 75,5 |
| 28 | 25 | 47 | 42 | 66 | 59 | 85 | 76 |
| 29 | 26 | 48 | 43 | 67 | 60 | 86 | 77 |
| 30 | 27 | 49 | 43,5 | 68 | 61 | 87 | 77,5 |
| 31 | 28 | 50 | 44,5 | 69 | 62 | 88 | 78,5 |
| 32 | 28,5 | 51 | 45,5 | 70 | 63 | 89 | 79,5 |
| 33 | 29,5 | 52 | 46,5 | 71 | 64 | | |
| 34 | 30,5 | 53 | 47,5 | 72 | 64,5 | | |

# TABLE 56
(SEE CONTINUATION)

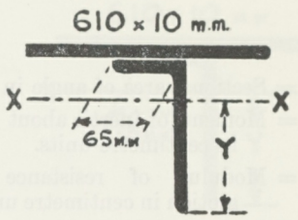
## GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of angle in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

ANGLES HAVING

| DEPTH OF WEB IN MILLIMETRES | ITEM | THICKNESS OF WEB IN MILLIMETRES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 5,0 | 5,5 | 6,0 | 6,5 | 7,0 | 7,5 | 8,0 | 8,5 | 9,0 |
| 65 | A | 6,36 | 6,95 | 7,53 | 8,12 | 8,70 | 9,28 | 9,85 | 10,4 | 11,0 |
| | I | 61,7 | 66,4 | 71,1 | 75,8 | 80,5 | 85,4 | 90,3 | 95,7 | 101 |
| | $I/_Y$ | 9,2 | 9,9 | 10,6 | 11,3 | 12,0 | 12,8 | 13,5 | 14,4 | 15,3 |
| 75 | A | 6,82 | 7,47 | 8,11 | 8,75 | 9,36 | 9,98 | 10,6 | 11,3 | 11,9 |
| | I | 85,4 | 93,2 | 101 | 109 | 116 | 124 | 132 | 140 | 147 |
| | $I/_Y$ | 11,0 | 12,1 | 13,1 | 14,2 | 15,2 | 16,3 | 17,4 | 18,5 | 19,5 |
| 80 | A | | | 8,42 | 9,07 | 9,71 | 10,4 | 11,0 | 11,7 | 12,3 |
| | I | | | 119 | 128 | 137 | 146 | 155 | 164 | 173 |
| | $I/_Y$ | | | 14,7 | 15,9 | 17,0 | 18,2 | 19,3 | 20,5 | 21,6 |
| 90 | A | | | 9,03 | 9,71 | 10,4 | 11,2 | 11,9 | 12,6 | 13,2 |
| | I | | | 165 | 177 | 188 | 201 | 213 | 225 | 236 |
| | $I/_Y$ | | | 18,2 | 19,5 | 20,8 | 22,3 | 23,8 | 25,2 | 26,6 |
| 100 | A | | | 9,73 | 10,5 | 11,2 | 12,0 | 12,8 | 13,5 | 14,2 |
| | I | | | 220 | 235 | 250 | 268 | 286 | 300 | 314 |
| | $I/_Y$ | | | 22,0 | 23,6 | 25,2 | 27,2 | 29,1 | 30,6 | 32,1 |
| 115 | A | | | 10,5 | 11,4 | 12,2 | 13,0 | 13,8 | 14,7 | 15,5 |
| | I | | | 319 | 344 | 368 | 392 | 416 | 439 | 462 |
| | $I/_Y$ | | | 28,1 | 30,4 | 32,7 | 35,0 | 37,3 | 39,5 | 41,7 |
| 130 | A | | | | | 13,3 | 14,2 | 15,1 | 16,0 | 16,9 |
| | I | | | | | 511 | 545 | 578 | 611 | 643 |
| | $I/_Y$ | | | | | 40,6 | 43,5 | 46,3 | 49,1 | 51,9 |

# GEOMETRICAL PROPERTIES OF SECTIONS




65 mm. FLANGE

| THICKNESS OF WEB IN MILLIMETRES | | | | | | | | ITEM | DEPTH OF WEB IN MILLIMETRES |
|---|---|---|---|---|---|---|---|---|---|
| 9,5 | 10,0 | 10,5 | 11,0 | 11,5 | 12,0 | 12,5 | 13,0 | | |
| 11,6 | 12,1 | 12,7 | 13,2 | 13,6 | 14,0 | 14,7 | 15,3 | A | 65 |
| 106 | 110 | 116 | 122 | 125 | 128 | 137 | 145 | I | |
| 16,1 | 16,8 | 17,7 | 18,6 | 19,1 | 19,6 | 21,0 | 22,3 | $I/_Y$ | |
| 12,5 | 13,1 | 13,7 | 14,3 | 14,9 | 15,5 | 16,1 | 16,6 | A | 75 |
| 154 | 161 | 168 | 176 | 184 | 192 | 201 | 210 | I | |
| 20,5 | 21,5 | 22,5 | 23,5 | 24,6 | 25,6 | 26,7 | 27,8 | $I/_Y$ | |
| 13,0 | 13,6 | 14,2 | 14,8 | 15,4 | 16,0 | 16,7 | 17,3 | A | 80 |
| 182 | 191 | 200 | 208 | 217 | 225 | 234 | 242 | I | |
| 22,8 | 24,0 | 25,2 | 26,3 | 27,5 | 28,6 | 29,8 | 30,9 | $I/_Y$ | |
| 13,9 | 14,6 | 15,3 | 16,0 | 16,7 | 17,4 | 18,0 | 18,6 | A | 90 |
| 248 | 260 | 272 | 284 | 296 | 308 | 321 | 334 | I | |
| 28,1 | 29,5 | 31,0 | 32,5 | 33,9 | 35,3 | 36,8 | 38,3 | $I/_Y$ | |
| 15,0 | 15,7 | 16,4 | 17,1 | 17,8 | 18,5 | 19,2 | 19,9 | A | 100 |
| 331 | 347 | 361 | 375 | 389 | 403 | 418 | 433 | I | |
| 33,9 | 35,7 | 37,3 | 38,9 | 40,5 | 42,1 | 43,7 | 45,3 | $I/_Y$ | |
| 16,3 | 17,1 | 17,9 | 18,7 | 19,5 | 20,3 | 21,1 | 21,9 | A | 115 |
| 485 | 507 | 520 | 533 | 546 | 559 | 573 | 587 | I | |
| 43,9 | 46,1 | 48,3 | 50,5 | 52,7 | 54,9 | 57,1 | 59,3 | $I/_Y$ | |
| 17,8 | 18,6 | 19,5 | 20,4 | 21,3 | 22,1 | 23,0 | 23,9 | A | 130 |
| 674 | 704 | 736 | 768 | 798 | 827 | 857 | 887 | I | |
| 54,6 | 57,2 | 60,1 | 62,9 | 65,6 | 68,3 | 71,0 | 73,7 | $I/_Y$ | |

# TABLE 56

(SEE CONTINUATION)

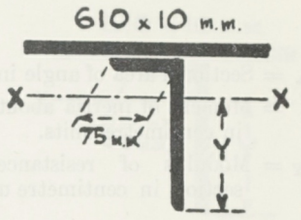
## GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of angle in square centimetres.
I = Moment of inertia about XX in centimetre units. } In conjunction with plating.
$^{I}/_{Y}$ = Modulus of resistance of section in centimetre units. }

ANGLES HAVING

| DEPTH OF WEB IN MILLIMETRES | ITEM | THICKNESS OF WEB IN MILLIMETRES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 6,0 | 6,5 | 7,0 | 7,5 | 8,0 | 8,5 | 9,0 | 9,5 | 10,0 |
| 75 | A | 8,79 | 9,45 | 10,1 | 10,9 | 11,5 | 12,2 | 12,8 | 13,5 | 14,1 |
| | I | 103 | 110 | 116 | 124 | 131 | 138 | 145 | 153 | 161 |
| | $^{I}/_{Y}$ | 13,4 | 14,3 | 15,1 | 16,3 | 17,3 | 18,3 | 19,3 | 20,4 | 21,5 |
| 90 | A | 9,61 | 10,4 | 11,1 | 11,9 | 12,6 | 13,4 | 14,1 | 14,9 | 15,6 |
| | I | 164 | 176 | 187 | 201 | 214 | 225 | 236 | 248 | 259 |
| | $^{I}/_{Y}$ | 18,1 | 19,5 | 20,8 | 22,4 | 23,9 | 25,3 | 26,6 | 28,0 | 29,3 |
| 100 | A | | | 11,9 | 12,8 | 13,6 | 14,4 | 15,1 | 15,9 | 16,7 |
| | I | | | 249 | 267 | 285 | 300 | 314 | 330 | 346 |
| | $^{I}/_{Y}$ | | | 25,1 | 27,0 | 28,9 | 30,6 | 32,2 | 33,9 | 35,6 |
| 120 | A | | | | | 15,1 | 16,0 | 16,8 | 17,7 | 18,6 |
| | I | | | | | 468 | 491 | 513 | 539 | 565 |
| | $^{I}/_{Y}$ | | | | | 40,3 | 42,4 | 44,5 | 47,0 | 49,4 |
| 130 | A | | | | | 15,9 | 16,9 | 17,8 | 18,7 | 19,6 |
| | I | | | | | 579 | 612 | 644 | 675 | 706 |
| | $^{I}/_{Y}$ | | | | | 46,4 | 49,2 | 52,0 | 54,7 | 57,4 |
| 140 | A | | | | | 16,7 | 17,7 | 18,7 | 19,7 | 20,6 |
| | I | | | | | 714 | 752 | 789 | 827 | 865 |
| | $^{I}/_{Y}$ | | | | | 53,4 | 56,5 | 59,6 | 62,7 | 65,8 |
| 150 | A | | | | | 17,5 | 18,5 | 19,5 | 20,6 | 21,6 |
| | I | | | | | 860 | 907 | 954 | 1000 | 1046 |
| | $^{I}/_{Y}$ | | | | | 60,5 | 64,1 | 67,7 | 71,3 | 74,9 |

# GEOMETRICAL PROPERTIES OF SECTIONS




75 mm. FLANGE

| THICKNESS OF WEB IN MILLIMETRES | | | | | | | | ITEM | DEPTH OF WEB IN MILLIMETRES |
|---|---|---|---|---|---|---|---|---|---|
| 10,5 | 11,0 | 11,5 | 12,0 | 12,5 | 13,0 | 13,5 | 14,0 | | |
| 14,8 | 15,4 | 16,1 | 16,7 | 17,4 | 18,1 | | | A | 75 |
| 167 | 173 | 181 | 189 | 197 | 204 | | | I | |
| 22,4 | 23,2 | 24,4 | 25,6 | 26,7 | 27,7 | | | $I/y$ | |
| 16,3 | 17,0 | 17,7 | 18,4 | 19,1 | 19,8 | | | A | 90 |
| 271 | 282 | 293 | 304 | 315 | 326 | | | I | |
| 30,8 | 32,2 | 33,5 | 34,8 | 36,1 | 37,4 | | | $I/y$ | |
| 17,5 | 18,2 | 19,0 | 19,7 | 20,5 | 21,2 | | | A | 100 |
| 361 | 376 | 391 | 406 | 421 | 436 | | | I | |
| 37,3 | 39,0 | 40,7 | 42,4 | 44,1 | 45,8 | | | $I/y$ | |
| 19,5 | 20,3 | 21,2 | 22,1 | 23,0 | 23,9 | | | A | 120 |
| 590 | 615 | 640 | 664 | 689 | 714 | | | I | |
| 51,8 | 54,1 | 56,5 | 58,9 | 61,3 | 63,7 | | | $I/y$ | |
| 20,6 | 21,5 | 22,4 | 23,3 | 24,2 | 25,1 | 26,0 | 26,9 | A | 130 |
| 738 | 770 | 799 | 827 | 856 | 884 | 912 | 939 | I | |
| 60,3 | 63,1 | 65,7 | 68,3 | 70,9 | 73,5 | 76,1 | 78,7 | $I/y$ | |
| 21,6 | 22,6 | 23,6 | 24,5 | 25,5 | 26,4 | 27,3 | 28,2 | A | 140 |
| 903 | 940 | 977 | 1014 | 1050 | 1086 | 1121 | 1156 | I | |
| 69,0 | 72,1 | 75,3 | 78,4 | 81,6 | 84,7 | 87,9 | 91,0 | $I/y$ | |
| 22,6 | 23,6 | 24,7 | 25,7 | 26,7 | 27,7 | 28,7 | 29,6 | A | 150 |
| 1091 | 1136 | 1181 | 1226 | 1269 | 1311 | 1353 | 1394 | I | |
| 78,5 | 82,0 | 85,6 | 89,2 | 92,7 | 96,1 | 99,6 | 103 | $I/y$ | |

TABLE 56
(SEE CONTINUATION)

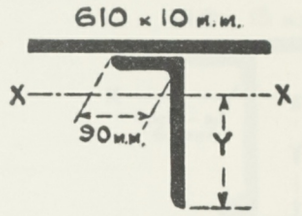
# GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of angle in square centimetres.
I = Moment of inertia about XX in centimetre units. } In conjunction with plating.
$I/_Y$ = Modulus of resistance of section in centimetre units. }

ANGLES HAVING

| DEPTH OF WEB IN MILLIMETRES | ITEM | THICKNESS OF WEB IN MILLIMETRES | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 7,0 | 7,5 | 8,0 | 8,5 | 9,0 | 9,5 | 10,0 | 10,5 | 11,0 | 11,5 |
| 90 | A | 12,0 | 12,9 | 13,8 | 14,6 | 15,5 | 16,3 | 17,1 | 17,9 | 18,7 | 19,5 |
| | I | 188 | 200 | 212 | 224 | 235 | 246 | 257 | 270 | 282 | 292 |
| | $I/_Y$ | 20,9 | 22,3 | 23,7 | 25,1 | 26,5 | 27,8 | 29,1 | 30,7 | 32,2 | 33,5 |
| 100 | A | | | 14,7 | 15,5 | 16,3 | 17,2 | 18,1 | 18,9 | 19,7 | 20,6 |
| | I | | | 283 | 297 | 311 | 328 | 345 | 359 | 372 | 388 |
| | $I/_Y$ | | | 28,8 | 30,3 | 31,8 | 33,7 | 35,6 | 37,1 | 38,6 | 40,4 |
| 110 | A | | | 15,5 | 16,4 | 17,3 | 18,3 | 19,2 | 20,1 | 20,9 | 21,8 |
| | I | | | 362 | 383 | 404 | 424 | 444 | 464 | 483 | 502 |
| | $I/_Y$ | | | 33,7 | 35,8 | 37,8 | 39,9 | 42,0 | 44,0 | 45,9 | 48,0 |
| 120 | A | | | | | 18,2 | 19,2 | 20,2 | 21,1 | 22,0 | 23,0 |
| | I | | | | | 517 | 541 | 564 | 590 | 616 | 640 |
| | $I/_Y$ | | | | | 44,8 | 47,1 | 49,3 | 51,8 | 54,2 | 56,5 |
| 130 | A | | | | | 19,2 | 20,2 | 21,2 | 22,2 | 23,2 | 24,2 |
| | I | | | | | 647 | 675 | 703 | 737 | 770 | 798 |
| | $I/_Y$ | | | | | 52,2 | 54,7 | 57,2 | 60,2 | 63,1 | 65,6 |
| 140 | A | | | | | 20,0 | 21,1 | 22,2 | 23,2 | 24,2 | 25,3 |
| | I | | | | | 786 | 826 | 865 | 901 | 937 | 974 |
| | $I/_Y$ | | | | | 59,3 | 62,6 | 65,8 | 68,8 | 71,8 | 75,0 |
| 150 | A | | | | | | | 23,2 | 24,3 | 25,3 | 26,4 |
| | I | | | | | | | 1044 | 1088 | 1132 | 1177 |
| | $I/_Y$ | | | | | | | 74,6 | 78,1 | 81,6 | 85,2 |
| 180 | A | | | | | | | 26,2 | 27,4 | 28,6 | 29,9 |
| | I | | | | | | | 1734 | 1806 | 1878 | 1950 |
| | $I/_Y$ | | | | | | | 105 | 110 | 115 | 120 |

# GEOMETRICAL PROPERTIES OF SECTIONS



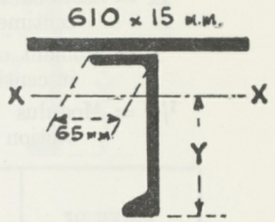

90 mm. FLANGE

| THICKNESS OF WEB IN MILLIMETRES | | | | | | | | | ITEM | DEPTH OF WEB IN MILLIMETRES |
|---|---|---|---|---|---|---|---|---|---|---|
| 12,0 | 12,5 | 13,0 | 13,5 | 14,0 | 14,5 | 15,0 | 15,5 | 16,0 | | |
| 20,3 | 21,1 | 21,8 | 22,6 | 23,4 | 24,2 | 24,9 | 25,7 | 26,4 | A | 90 |
| 302 | 315 | 327 | 336 | 344 | 358 | 371 | 382 | 393 | I | |
| 34,7 | 36,3 | 37,8 | 38,9 | 40,0 | 41,7 | 43,4 | 44,8 | 46,1 | $I/y$ | |
| 21,5 | 22,3 | 23,0 | 23,8 | 24,5 | 25,3 | 26,0 | 26,8 | 27,5 | A | 100 |
| 403 | 418 | 432 | 447 | 461 | 476 | 490 | 504 | 518 | I | |
| 42,1 | 43,8 | 45,4 | 47,1 | 48,7 | 50,4 | 52,0 | 53,7 | 55,3 | $I/y$ | |
| 22,7 | 23,6 | 24,5 | 25,4 | 26,2 | 27,1 | 27,9 | 28,8 | 29,6 | A | 110 |
| 521 | 541 | 560 | 579 | 597 | 616 | 634 | 652 | 670 | I | |
| 50,0 | 52,0 | 54,0 | 56,0 | 58,0 | 60,0 | 62,0 | 64,0 | 66,0 | $I/y$ | |
| 23,9 | 24,9 | 25,8 | 26,8 | 27,7 | 28,7 | 29,6 | 30,6 | 31,5 | A | 120 |
| 663 | 686 | 709 | 732 | 755 | 778 | 801 | 824 | 846 | I | |
| 58,8 | 61,0 | 63,2 | 65,4 | 67,6 | 69,8 | 72,0 | 74,2 | 76,4 | $I/y$ | |
| 25,1 | 26,1 | 27,1 | 28,1 | 29,0 | 30,0 | 31,0 | 32,0 | 33,0 | A | 130 |
| 825 | 854 | 882 | 912 | 942 | 972 | 1002 | 1031 | 1060 | I | |
| 68,1 | 70,7 | 73,3 | 76,1 | 78,9 | 81,6 | 84,2 | 86,9 | 89,5 | $I/y$ | |
| 26,3 | 27,3 | 28,3 | 29,4 | 30,4 | 31,4 | 32,4 | 33,5 | 34,5 | A | 140 |
| 1011 | 1047 | 1083 | 1118 | 1153 | 1188 | 1223 | 1258 | 1292 | I | |
| 78,1 | 81,2 | 84,3 | 87,3 | 90,3 | 93,3 | 96,3 | 99,3 | 102,3 | $I/y$ | |
| 27,5 | 28,6 | 29,7 | 30,8 | 31,8 | 32,9 | 33,9 | 35,0 | 36,0 | A | 150 |
| 1221 | 1263 | 1305 | 1348 | 1391 | 1433 | 1475 | 1517 | 1559 | I | |
| 88,7 | 92,1 | 95,5 | 99,3 | 103 | 107 | 110 | 114 | 117 | $I/y$ | |
| 31,1 | 32,4 | 33,6 | 34,8 | 36,0 | 37,2 | 38,4 | 39,6 | 40,8 | A | 180 |
| 2021 | 2092 | 2162 | 2231 | 2299 | 2367 | 2434 | 2502 | 2569 | I | |
| 125 | 130 | 135 | 140 | 145 | 150 | 155 | 160 | 165 | $I/y$ | |

# GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of bulb angles in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

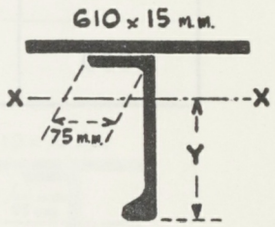
## BULB ANGLES HAVING 65 mm. FLANGE




| DEPTH OF WEB IN MILLIMETRES | ITEM | THICKNESS OF WEB IN MILLIMETRES | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 7,0 | 7,5 | 8,0 | 8,5 | 9,0 | 9,5 | 10,0 |
| 130 | A | 15,4 | 16,2 | 17,0 | 17,8 | 18,6 | 19,4 | 20,1 |
| | I | 874 | 914 | 954 | 993 | 1032 | 1069 | 1106 |
| | $I/_Y$ | 68,1 | 71,4 | 74,7 | 78,1 | 81,4 | 84,6 | 87,7 |
| 140 | A | 16,6 | 17,4 | 18,2 | 19,1 | 19,9 | 20,8 | 21,6 |
| | I | 1111 | 1157 | 1203 | 1250 | 1296 | 1343 | 1390 |
| | $I/_Y$ | 81,2 | 84,8 | 88,4 | 92,2 | 95,9 | 100 | 104 |

A = Sectional area of bulb angles in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

## BULB ANGLES HAVING 75 mm. FLANGE




| DEPTH OF WEB IN MILLIMETRES | ITEM | THICKNESS OF WEB IN MILLIMETRES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 7,0 | 7,5 | 8,0 | 8,5 | 9,0 | 9,5 | 10,0 | 10,5 | 11,0 | 11,5 | 12,0 |
| 150 | A | 18,5 | 19,4 | 20,3 | 21,2 | 22,1 | 23,0 | 23,9 | 24,8 | | | |
| | I | 1406 | 1461 | 1516 | 1571 | 1627 | 1682 | 1737 | 1791 | | | |
| | $I/_Y$ | 97,0 | 101 | 105 | 109 | 114 | 118 | 122 | 126 | | | |
| 165 | A | | | 22,2 | 23,2 | 24,1 | 25,1 | 26,1 | 27,1 | 28,0 | | |
| | I | | | 2001 | 2070 | 2139 | 2210 | 2281 | 2349 | 2416 | | |
| | $I/_Y$ | | | 128 | 133 | 138 | 143 | 148 | 153 | 158 | | |
| 180 | A | | | 24,2 | 25,3 | 26,3 | 27,4 | 28,4 | 29,5 | 30,5 | | |
| | I | | | 2656 | 2740 | 2824 | 2912 | 2999 | 3084 | 3168 | | |
| | $I/_Y$ | | | 158 | 164 | 169 | 175 | 181 | 187 | 192 | | |
| 200 | A | | | | | 29,3 | 30,5 | 31,6 | 32,8 | 33,9 | 35,1 | 36,2 |
| | I | | | | | 3919 | 4032 | 4144 | 4252 | 4359 | 4465 | 4571 |
| | $I/_Y$ | | | | | 214 | 222 | 229 | 236 | 243 | 250 | 256 |

TABLE 56
(SEE CONTINUATION)

# GEOMETRICAL PROPERTIES OF SECTIONS

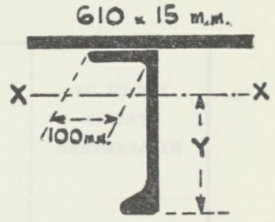
A = Sectional area of bulb angles in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

## BULB ANGLES HAVING

| DEPTH OF WEB IN MILLIMETRES | ITEM | THICKNESS OF WEB IN MILLIMETRES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 8,0 | 8,5 | 9,0 | 9,5 | 10,0 | 10,5 | 11,0 | 11,5 | 12,0 |
| 180 | A | 25,5 | 26,6 | 27,7 | 28,8 | 29,9 | 31,0 | 32,1 | 33,1 | |
| | I | 2647 | 2737 | 2827 | 2917 | 3001 | 3085 | 3166 | 3247 | |
| | $I/_Y$ | 157 | 163 | 169 | 175 | 181 | 187 | 192 | 197 | |
| 200 | A | | | | | 33,4 | 34,6 | 35,8 | 37,0 | 38,1 |
| | I | | | | | 4120 | 4234 | 4348 | 4457 | 4566 |
| | $I/_Y$ | | | | | 227 | 234 | 241 | 249 | 256 |
| 230 | A | | | | | | | 40,8 | 42,2 | 43,5 |
| | I | | | | | | | 6567 | 6718 | 6869 |
| | $I/_Y$ | | | | | | | 325 | 334 | 343 |
| 250 | A | | | | | | | 44,6 | 46,0 | 47,4 |
| | I | | | | | | | 8679 | 8871 | 9062 |
| | $I/_Y$ | | | | | | | 403 | 414 | 424 |
| 280 | A | | | | | | | | | 53,1 |
| | I | | | | | | | | | 12690 |
| | $I/_Y$ | | | | | | | | | 543 |
| 300 | A | | | | | | | | | |
| | I | | | | | | | | | |
| | $I/_Y$ | | | | | | | | | |

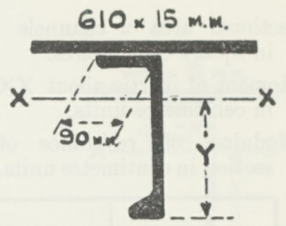
A = Sectional area of bulb angles in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

## BULB ANGLES HAVING 100 mm. FLANGE




| DEPTH OF WEB IN MILLIMETRES | ITEM | THICKNESS OF WEB IN MILLIMETRES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 13,0 | 13,5 | 14,0 | 14,5 | 15,0 | 15,5 | 16,0 | 16,5 | 17,0 | 17,5 | 18,0 |
| 320 | A | 64,8 | 66,6 | 68,4 | 70,2 | 72,0 | 73,8 | 75,6 | 77,4 | 79,2 | | |
| | I | 19080 | 19440 | 19790 | 20060 | 20330 | 20670 | 21010 | 21330 | 21650 | | |
| | $I/_Y$ | 737 | 754 | 771 | 784 | 797 | 814 | 831 | 847 | 862 | | |
| 340 | A | 70,5 | 72,4 | 74,3 | 76,2 | 78,1 | 80,0 | 81,9 | 83,8 | 85,7 | | |
| | I | 23840 | 24270 | 24700 | 25030 | 25360 | 25690 | 26020 | 26410 | 26790 | | |
| | $I/_Y$ | 888 | 908 | 928 | 944 | 959 | 975 | 991 | 1010 | 1028 | | |
| 380 | A | | | | 86,0 | 88,1 | 90,2 | 92,3 | 94,4 | 96,5 | 98,8 | 101 |
| | I | | | | 34990 | 35300 | 35740 | 36170 | 36710 | 37240 | 37670 | 38100 |
| | $I/_Y$ | | | | 1217 | 1231 | 1251 | 1271 | 1295 | 1319 | 1338 | 1357 |

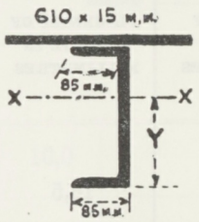
# GEOMETRICAL PROPERTIES OF SECTIONS




## 90 mm. FLANGE

| THICKNESS OF WEB IN MILLIMETRES | | | | | | | | ITEM | DEPTH OF WEB IN MILLIMETRES |
|---|---|---|---|---|---|---|---|---|---|
| 12,5 | 13,0 | 13,5 | 14,0 | 14,5 | 15,0 | 15,5 | 16,0 | | |
| | | | | | | | | A<br>I<br>$I/_Y$ | 180 |
| 39,3<br>4672<br>263 | 40,4<br>4778<br>269 | | | | | | | A<br>I<br>$I/_Y$ | 200 |
| 44,8<br>7021<br>352 | 46,1<br>7172<br>360 | | | | | | | A<br>I<br>$I/_Y$ | 230 |
| 48,9<br>9252<br>435 | 50,3<br>9442<br>446 | 51,8<br>9594<br>455 | 53,2<br>9745<br>463 | | | | | A<br>I<br>$I/_Y$ | 250 |
| 54,7<br>12900<br>554 | 56,3<br>13110<br>565 | 57,9<br>13360<br>578 | 59,4<br>13610<br>591 | 61,0<br>13860<br>604 | | | | A<br>I<br>$I/_Y$ | 280 |
| | 60,9<br>16310<br>668 | 62,6<br>16610<br>683 | 64,2<br>16910<br>698 | 65,9<br>17150<br>711 | 67,6<br>17380<br>723 | 69,3<br>17670<br>738 | 71,0<br>17960<br>753 | A<br>I<br>$I/_Y$ | 300 |

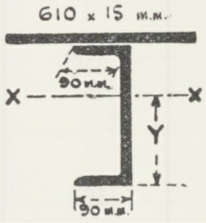
A = Sectional area of channels in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.




## CHANNELS HAVING 85 mm. FLANGE

| DEPTH OF WEB IN MILLIMETRES | THICKNESS OF FLANGE IN MILLIMETRES | ITEM | THICKNESS OF WEB IN MILLIMETRES | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 11,0 | 11,5 | 12,0 | 12,5 | 13,0 | 13,5 | 14,0 |
| 200 | 14 | A<br>I<br>$I/_Y$ | 43,3<br>5974<br>346 | 44,3<br>6061<br>352 | 45,3<br>6148<br>358 | 46,3<br>6233<br>364 | 47,3<br>6318<br>370 | 48,3<br>6397<br>376 | 49,3<br>6476<br>381 |

A = Sectional area of channels in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.




## CHANNELS HAVING 90 mm. FLANGE

| DEPTH OF WEB IN MILLIMETRES | THICKNESS OF FLANGE IN MILLIMETRES | ITEM | THICKNESS OF WEB IN MILLIMETRES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 11,0 | 11,5 | 12,0 | 12,5 | 13,0 | 13,5 | 14,0 | 14,5 | 15,0 |
| 220 | 15 | A<br>I<br>$I/_Y$ | 48,6<br>7919<br>424 | 49,7<br>8027<br>431 | 50,8<br>8134<br>438 | 51,9<br>8241<br>446 | 53,0<br>8348<br>453 | 54,1<br>8449<br>460 | 55,2<br>8549<br>467 | 56,3<br>8650<br>474 | 57,4<br>8751<br>480 |

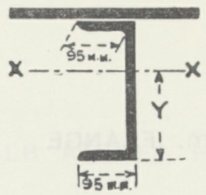
# TABLE 56

(SEE CONTINUATION)

## GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of channels in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

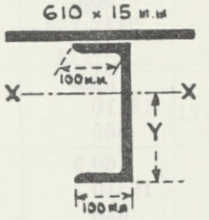
### CHANNELS HAVING 95 mm. FLANGE




| DEPTH OF WEB IN MILLIMETRES | THICKNESS OF FLANGE IN MILLIMETRES | ITEM | THICKNESS OF WEB IN MILLIMETRES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 12,0 | 12,5 | 13,0 | 13,5 | 14,0 | 14,5 | 15,0 | 15,5 | 16,0 |
| 240 | 15,5 | A | 55,2 | 56,4 | 57,6 | 58,8 | 60,0 | 61,2 | 62,4 | 63,6 | 64,8 |
| | | I | 10300 | 10440 | 10570 | 10700 | 10830 | 10960 | 11090 | 11220 | 11340 |
| | | $I/_Y$ | 516 | 525 | 533 | 541 | 549 | 558 | 566 | 574 | 582 |
| 260 | 16 | A | 58,5 | 59,8 | 61,1 | 62,4 | 63,7 | 65,0 | 66,3 | 67,6 | 68,9 |
| | | I | 12560 | 12730 | 12890 | 13060 | 13220 | 13380 | 13530 | 13680 | 13830 |
| | | $I/_Y$ | 587 | 597 | 607 | 617 | 626 | 636 | 645 | 654 | 663 |

A = Sectional area of channels in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

### CHANNELS HAVING 100 mm. FLANGE

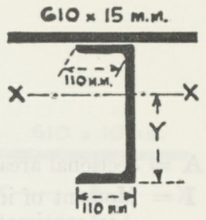



| DEPTH OF WEB IN MILLIMETRES | THICKNESS OF FLANGE IN MILLIMETRES | ITEM | THICKNESS OF WEB IN MILLIMETRES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 13,0 | 13,5 | 14,0 | 14,5 | 15,0 | 15,5 | 16,0 | 16,5 | 17,0 | 17,5 | 18,0 |
| 280 | 16,5 | A | 65,9 | 67,3 | 68,7 | 70,1 | 71,5 | 72,9 | 74,3 | 75,7 | 77,1 | | |
| | | I | 15830 | 16020 | 16210 | 16390 | 16570 | 16760 | 16950 | 17140 | 17320 | | |
| | | $I/_Y$ | 701 | 712 | 723 | 734 | 744 | 755 | 765 | 776 | 787 | | |
| 300 | 17 | A | 69,1 | 70,6 | 72,1 | 73,6 | 75,1 | 76,6 | 78,1 | 79,6 | 81,1 | | |
| | | I | 18700 | 18930 | 19160 | 19390 | 19620 | 19840 | 20060 | 20280 | 20490 | | |
| | | $I/_Y$ | 779 | 792 | 804 | 817 | 829 | 842 | 854 | 866 | 877 | | |
| 320 | 17,5 | A | 72,6 | 74,2 | 75,8 | 77,4 | 79,0 | 80,6 | 82,2 | 83,8 | 85,4 | 87,0 | 88,6 |
| | | I | 22000 | 22270 | 22530 | 22800 | 23060 | 23330 | 23600 | 23850 | 24100 | 24360 | 24610 |
| | | $I/_Y$ | 869 | 883 | 896 | 910 | 923 | 937 | 950 | 964 | 978 | 991 | 1004 |
| 350 | 16 | A | 73,8 | 75,6 | 77,3 | 79,1 | 80,8 | 82,6 | 84,3 | 86,1 | 87,8 | 89,6 | 91,3 |
| | | I | 26140 | 26480 | 26810 | 27150 | 27480 | 27840 | 28190 | 28510 | 28830 | 29170 | 29510 |
| | | $I/_Y$ | 947 | 963 | 979 | 995 | 1011 | 1028 | 1044 | 1060 | 1075 | 1092 | 1108 |
| 380 | 16 | A | 78,5 | 80,3 | 82,1 | 84,1 | 86,0 | 87,9 | 89,8 | 91,7 | 93,6 | 95,5 | 97,4 |
| | | I | 32180 | 32590 | 33000 | 33440 | 33870 | 34290 | 34710 | 35140 | 35570 | 35990 | 36400 |
| | | $I/_Y$ | 1085 | 1103 | 1121 | 1141 | 1160 | 1179 | 1197 | 1216 | 1235 | 1255 | 1274 |

# GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of channels in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

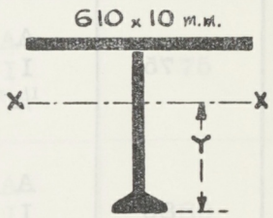
## CHANNELS HAVING 110 mm. FLANGE




| DEPTH OF WEB IN MILLIMETRES | THICKNESS OF FLANGE IN MILLIMETRES | ITEM | THICKNESS OF WEB IN MILLIMETRES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 14,0 | 14,5 | 15,0 | 15,5 | 16,0 | 16,5 | 17,0 | 17,5 | 18,0 |
| 400 | 18 | A | 91,5 | 93,5 | 95,5 | 97,5 | 99,5 | 102 | 104 | 106 | 108 |
| | | I | 40060 | 40550 | 41030 | 41500 | 41970 | 42420 | 42870 | 43330 | 43790 |
| | | $I/_Y$ | 1319 | 1340 | 1361 | 1382 | 1402 | 1422 | 1442 | 1462 | 1482 |

A = Sectional area of bulb plates in square centimetres.
I = Moment of inertia about XX in centimetre units.
$I/_Y$ = Modulus of resistance of section in centimetre units.
} In conjunction with plating.

## BULB PLATES




| DEPTH OF WEB IN MILLIMETRES | ITEM | THICKNESS OF WEB IN MILLIMETRES | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 6,0 | 6,5 | 7,0 | 7,5 | 8,0 | 8,5 | 9,0 | 9,5 | 10,0 | |
| 130 | A | 10,4 | 11,1 | 11,7 | 12,4 | 13,0 | | | | | |
| | I | 809 | 840 | 870 | 901 | 931 | | | | | |
| | $I/_Y$ | 65,9 | 68,7 | 71,5 | 74,3 | 77,1 | | | | | |
| 140 | A | 11,0 | 11,7 | 12,4 | 13,1 | 13,8 | | | | | |
| | I | 969 | 1006 | 1042 | 1079 | 1115 | | | | | |
| | $I/_Y$ | 73,8 | 77,0 | 80,1 | 83,3 | 86,5 | | | | | |
| 160 | A | | | 14,6 | 15,4 | 16,2 | 17,0 | 17,8 | | | |
| | I | | | 1585 | 1637 | 1688 | 1736 | 1784 | | | |
| | $I/_Y$ | | | 109 | 113 | 117 | 121 | 125 | | | |
| 180 | A | | | | | 18,7 | 19,6 | 20,5 | 21,4 | 22,3 | |
| | I | | | | | 2431 | 2507 | 2582 | 2635 | 2687 | |
| | $I/_Y$ | | | | | 153 | 159 | 165 | 169 | 173 | |

# TABLE 56

(SEE CONTINUATION)

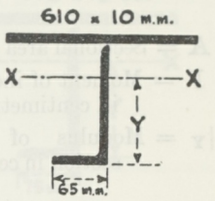
## GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of angle in square centimetres.
I = Moment of inertia about XX in centimetre units. } In conjunction with plating.
$I/_Y$ = Modulus of resistance of section in centimetre units. }

INVERTED ANGLES

| DEPTH OF WEB IN MILLIMETRES | ITEM | THICKNESS OF WEB IN MILLIMETRES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 5,0 | 5,5 | 6,0 | 6,5 | 7,0 | 7,5 | 8,0 | 8,5 | 9,0 |
| 65 | A | 6,36 | 6,95 | 7,53 | 8,12 | 8,70 | 9,28 | 9,85 | 10,4 | 11,0 |
| | I | 187 | 201 | 214 | 228 | 241 | 252 | 262 | 274 | 286 |
| | $I/_Y$ | 28,8 | 31,1 | 33,3 | 35,6 | 37,8 | 39,8 | 41,7 | 43,9 | 46,0 |
| 75 | A | 6,82 | 7,47 | 8,11 | 8,75 | 9,36 | 9,98 | 10,6 | 11,3 | 11,9 |
| | I | 252 | 272 | 291 | 309 | 325 | 341 | 357 | 373 | 389 |
| | $I/_Y$ | 34,1 | 36,9 | 39,7 | 42,5 | 44,9 | 47,5 | 50,0 | 52,5 | 55,0 |
| 80 | A | | | 8,42 | 9,07 | 9,71 | 10,4 | 11,0 | 11,7 | 12,3 |
| | I | | | 336 | 355 | 374 | 393 | 412 | 430 | 447 |
| | $I/_Y$ | | | 43,2 | 46,0 | 48,8 | 51,6 | 54,4 | 57,1 | 59,7 |
| 90 | A | | | 9,03 | 9,71 | 10,4 | 11,2 | 11,9 | 12,6 | 13,2 |
| | I | | | 431 | 458 | 485 | 511 | 537 | 559 | 581 |
| | $I/_Y$ | | | 49,9 | 53,4 | 56,8 | 60,3 | 63,8 | 66,8 | 69,8 |
| 100 | A | | | 9,73 | 10,5 | 11,2 | 12,0 | 12,8 | 13,5 | 14,2 |
| | I | | | 548 | 583 | 618 | 650 | 681 | 711 | 740 |
| | $I/_Y$ | | | 57,7 | 61,9 | 66,0 | 69,8 | 73,6 | 77,3 | 80,9 |
| 115 | A | | | 10,5 | 11,4 | 12,2 | 13,0 | 13,8 | 14,7 | 15,5 |
| | I | | | 745 | 793 | 841 | 883 | 924 | 967 | 1009 |
| | $I/_Y$ | | | 69,0 | 74,0 | 78,9 | 83,4 | 87,9 | 92,5 | 97,1 |
| 130 | A | | | | | 13,3 | 14,2 | 15,1 | 16,0 | 16,9 |
| | I | | | | | 1120 | 1178 | 1235 | 1289 | 1343 |
| | $I/_Y$ | | | | | 94,2 | 100 | 105 | 111 | 116 |

# GEOMETRICAL PROPERTIES OF SECTIONS




HAVING 65 mm. FLANGE

| THICKNESS OF WEB IN MILLIMETRES | | | | | | | | ITEM | DEPTH OF WEB IN MILLIMETRES |
|---|---|---|---|---|---|---|---|---|---|
| 9,5 | 10,0 | 10,5 | 11,0 | 11,5 | 12,0 | 12,5 | 13,0 | | |
| 11,6 | 12,1 | 12,7 | 13,2 | 13,6 | 14,0 | 14,7 | 15,3 | A | 65 |
| 296 | 306 | 316 | 325 | 332 | 338 | 347 | 355 | I | |
| 47,8 | 49,6 | 51,4 | 53,2 | 54,5 | 55,7 | 57,4 | 59,0 | $I/y$ | |
| 12,5 | 13,1 | 13,7 | 14,3 | 14,9 | 15,5 | 16,1 | 16,6 | A | 75 |
| 404 | 418 | 432 | 446 | 460 | 474 | 488 | 501 | I | |
| 57,4 | 59,7 | 62,1 | 64,4 | 66,7 | 68,9 | 71,1 | 73,2 | $I/y$ | |
| 13,0 | 13,6 | 14,2 | 14,8 | 15,4 | 16,0 | 16,7 | 17,3 | A | 80 |
| 464 | 481 | 496 | 510 | 524 | 537 | 552 | 567 | I | |
| 62,3 | 64,9 | 67,2 | 69,4 | 71,6 | 73,8 | 76,2 | 78,6 | $I/y$ | |
| 13,9 | 14,6 | 15,3 | 16,0 | 16,7 | 17,4 | 18,0 | 18,6 | A | 90 |
| 604 | 626 | 649 | 671 | 694 | 716 | 738 | 760 | I | |
| 72,9 | 76,0 | 79,0 | 82,0 | 84,9 | 87,8 | 90,7 | 93,6 | $I/y$ | |
| 15,0 | 15,7 | 16,4 | 17,1 | 17,8 | 18,5 | 19,2 | 19,9 | A | 100 |
| 768 | 795 | 821 | 846 | 872 | 897 | 922 | 947 | I | |
| 84,4 | 87,9 | 91,2 | 94,5 | 97,8 | 101 | 105 | 108 | $I/y$ | |
| 16,3 | 17,1 | 17,9 | 18,7 | 19,5 | 20,3 | 21,1 | 21,9 | A | 115 |
| 1047 | 1085 | 1123 | 1161 | 1198 | 1235 | 1271 | 1307 | I | |
| 102 | 106 | 111 | 115 | 120 | 124 | 129 | 133 | $I/y$ | |
| 17,8 | 18,6 | 19,5 | 20,4 | 21,3 | 22,1 | 23,0 | 23,9 | A | 130 |
| 1393 | 1443 | 1491 | 1538 | 1582 | 1625 | 1668 | 1710 | I | |
| 121 | 126 | 131 | 136 | 141 | 146 | 151 | 156 | $I/y$ | |

# TABLE 56
(SEE CONTINUATION)

## GEOMETRICAL PROPERTIES OF SECTIONS

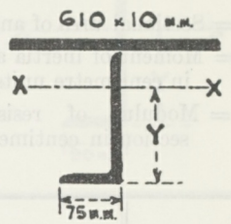
A = Sectional area of angle in square centimetres.
I = Moment of inertia about XX in centimetre units. } In conjunction with plating.
$I/_Y$ = Modulus of resistance of section in centimetre units. }

INVERTED ANGLES

| DEPTH OF WEB IN MILLIMETRES | ITEM | THICKNESS OF WEB IN MILLIMETRES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 6,0 | 6,5 | 7,0 | 7,5 | 8,0 | 8,5 | 9,0 | 9,5 | 10,0 |
| 75 | A | 8,79 | 9,45 | 10,1 | 10,9 | 11,5 | 12,2 | 12,8 | 13,5 | 14,1 |
| | I | 321 | 341 | 360 | 382 | 397 | 414 | 430 | 446 | 461 |
| | $I/_Y$ | 44,3 | 47,3 | 50,3 | 53,7 | 56,2 | 58,9 | 61,5 | 64,1 | 66,7 |
| 90 | A | 9,61 | 10,4 | 11,1 | 11,9 | 12,6 | 13,4 | 14,1 | 14,9 | 15,6 |
| | I | 473 | 502 | 531 | 557 | 583 | 609 | 635 | 661 | 686 |
| | $I/_Y$ | 55,2 | 59,1 | 62,9 | 66,5 | 70,0 | 73,6 | 77,1 | 80,8 | 84,4 |
| 100 | A | | | 11,9 | 12,8 | 13,6 | 14,4 | 15,1 | 15,9 | 16,7 |
| | I | | | 675 | 710 | 744 | 776 | 807 | 837 | 867 |
| | $I/_Y$ | | | 72,7 | 77,1 | 81,4 | 85,4 | 89,3 | 93,2 | 97,1 |
| 120 | A | | | | | 15,1 | 16,0 | 16,8 | 17,7 | 18,6 |
| | I | | | | | 1110 | 1159 | 1208 | 1255 | 1302 |
| | $I/_Y$ | | | | | 103 | 108 | 113 | 119 | 124 |
| 130 | A | | | | | 15,9 | 16,9 | 17,8 | 18,7 | 19,6 |
| | I | | | | | 1335 | 1393 | 1451 | 1504 | 1557 |
| | $I/_Y$ | | | | | 115 | 121 | 127 | 133 | 138 |
| 140 | A | | | | | 16,7 | 17,7 | 18,7 | 19,7 | 20,6 |
| | I | | | | | 1592 | 1655 | 1718 | 1781 | 1844 |
| | $I/_Y$ | | | | | 129 | 135 | 141 | 147 | 153 |
| 150 | A | | | | | 17,5 | 18,5 | 19,5 | 20,6 | 21,6 |
| | I | | | | | 1848 | 1927 | 2005 | 2083 | 2160 |
| | $I/_Y$ | | | | | 140 | 147 | 154 | 161 | 168 |

# GEOMETRICAL PROPERTIES OF SECTIONS

HAVING 75 mm. FLANGE




| THICKNESS OF WEB IN MILLIMETRES | | | | | | | | ITEM | DEPTH OF WEB IN MILLIMETRES |
|---|---|---|---|---|---|---|---|---|---|
| 10,5 | 11,0 | 11,5 | 12,0 | 12,5 | 13,0 | 13,5 | 14,0 | | |
| 14,8 | 15,4 | 16,1 | 16,7 | 17,4 | 18,1 | | | A | 75 |
| 475 | 489 | 502 | 515 | 530 | 545 | | | I | |
| 69,1 | 71,5 | 73,8 | 76,1 | 78,8 | 81,4 | | | $I/y$ | |
| 16,3 | 17,0 | 17,7 | 18,4 | 19,1 | 19,8 | | | A | 90 |
| 706 | 726 | 747 | 767 | 788 | 808 | | | I | |
| 87,4 | 90,3 | 93,3 | 96,3 | 99,3 | 102 | | | $I/y$ | |
| 17,5 | 18,2 | 19,0 | 19,7 | 20,5 | 21,2 | | | A | 100 |
| 895 | 922 | 947 | 972 | 985 | 997 | | | I | |
| 101 | 105 | 108 | 111 | 114 | 117 | | | $I/y$ | |
| 19,5 | 20,3 | 21,2 | 22,1 | 23,0 | 23,9 | | | A | 120 |
| 1343 | 1383 | 1425 | 1466 | 1508 | 1549 | | | I | |
| 129 | 133 | 138 | 143 | 148 | 153 | | | $I/y$ | |
| 20,6 | 21,5 | 22,4 | 23,3 | 24,2 | 25,1 | 26,0 | 26,9 | A | 130 |
| 1609 | 1660 | 1709 | 1757 | 1806 | 1854 | 1903 | 1951 | I | |
| 144 | 149 | 155 | 160 | 166 | 171 | 176 | 182 | $I/y$ | |
| 21,6 | 22,6 | 23,6 | 24,5 | 25,5 | 26,4 | 27,3 | 28,2 | A | 140 |
| 1906 | 1968 | 2023 | 2078 | 2133 | 2187 | 2241 | 2295 | I | |
| 159 | 165 | 171 | 177 | 183 | 188 | 194 | 199 | $I/y$ | |
| 22,6 | 23,6 | 24,7 | 25,7 | 26,7 | 27,7 | 28,7 | 29,6 | A | 150 |
| 2229 | 2297 | 2367 | 2436 | 2498 | 2560 | 2617 | 2674 | I | |
| 175 | 181 | 188 | 195 | 201 | 207 | 213 | 219 | $I/y$ | |

# TABLE 56

(SEE CONTINUATION)

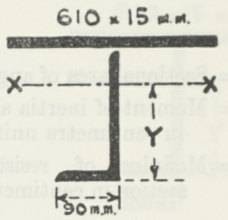
## GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of angle in square centimetres.
I = Moment of inertia about XX in centimetre units. } In conjunction with plating.
$I/_Y$ = Modulus of resistance of section in centimetre units. }

INVERTED ANGLES

| DEPTH OF WEB IN MILLIMETRES | ITEM | THICKNESS OF WEB IN MILLIMETRES | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 7,0 | 7,5 | 8,0 | 8,5 | 9,0 | 9,5 | 10,0 | 10,5 | 11,0 | 11,5 |
| 90 | A | 12,0 | 12,9 | 13,8 | 14,6 | 15,5 | 16,3 | 17,1 | 17,9 | 18,7 | 19,5 |
| | I | 674 | 711 | 748 | 785 | 822 | 853 | 883 | 914 | 945 | 973 |
| | $I/_Y$ | 75,6 | 80,3 | 85,0 | 89,7 | 94,4 | 98,7 | 103 | 107 | 111 | 115 |
| 100 | A | | | 14,7 | 15,5 | 16,3 | 17,2 | 18,1 | 18,9 | 19,7 | 20,6 |
| | I | | | 941 | 983 | 1024 | 1064 | 1104 | 1142 | 1179 | 1217 |
| | $I/_Y$ | | | 97,5 | 102 | 107 | 112 | 117 | 122 | 126 | 131 |
| 110 | A | | | 15,5 | 16,4 | 17,3 | 18,3 | 19,2 | 20,1 | 20,9 | 21,8 |
| | I | | | 1158 | 1209 | 1260 | 1313 | 1365 | 1409 | 1453 | 1497 |
| | $I/_Y$ | | | 110 | 116 | 121 | 127 | 133 | 138 | 143 | 148 |
| 120 | A | | | | | 18,2 | 19,2 | 20,2 | 21,1 | 22,0 | 23,0 |
| | I | | | | | 1518 | 1583 | 1647 | 1699 | 1750 | 1806 |
| | $I/_Y$ | | | | | 135 | 142 | 148 | 154 | 159 | 165 |
| 130 | A | | | | | 19,2 | 20,2 | 21,2 | 22,2 | 23,2 | 24,2 |
| | I | | | | | 1812 | 1887 | 1962 | 2028 | 2093 | 2156 |
| | $I/_Y$ | | | | | 150 | 157 | 164 | 171 | 177 | 184 |
| 140 | A | | | | | 20,0 | 21,1 | 22,2 | 23,2 | 24,2 | 25,3 |
| | I | | | | | 2132 | 2220 | 2307 | 2386 | 2465 | 2540 |
| | $I/_Y$ | | | | | 165 | 173 | 181 | 188 | 195 | 202 |
| 150 | A | | | | | | | 23,2 | 24,3 | 25,3 | 26,4 |
| | I | | | | | | | 2694 | 2786 | 2877 | 2964 |
| | $I/_Y$ | | | | | | | 199 | 207 | 214 | 222 |
| 180 | A | | | | | | | 26,2 | 27,4 | 28,6 | 29,9 |
| | I | | | | | | | 4054 | 4193 | 4332 | 4467 |
| | $I/_Y$ | | | | | | | 254 | 265 | 275 | 285 |

# GEOMETRICAL PROPERTIES OF SECTIONS




HAVING 90 mm. FLANGE

| THICKNESS OF WEB IN MILLIMETRES | | | | | | | | | ITEM | DEPTH OF WEB IN MILLIMETRES |
|---|---|---|---|---|---|---|---|---|---|---|
| 12,0 | 12,5 | 13,0 | 13,5 | 14,0 | 14,5 | 15,0 | 15,5 | 16,0 | | |
| 20,3 | 21,1 | 21,8 | 22,6 | 23,4 | 24,2 | 24,9 | 25,7 | 26,4 | A | 90 |
| 1001 | 1026 | 1051 | 1075 | 1099 | 1124 | 1148 | 1169 | 1190 | I | |
| 118 | 122 | 125 | 129 | 132 | 136 | 139 | 142 | 145 | I/Y | |
| 21,5 | 22,3 | 23,0 | 23,8 | 24,5 | 25,3 | 26,0 | 26,8 | 27,5 | A | 100 |
| 1254 | 1285 | 1315 | 1343 | 1370 | 1393 | 1415 | 1433 | 1450 | I | |
| 135 | 139 | 143 | 148 | 152 | 157 | 161 | 166 | 170 | I/Y | |
| 22,7 | 23,6 | 24,5 | 25,4 | 26,2 | 27,1 | 27,9 | 28,8 | 29,6 | A | 110 |
| 1541 | 1584 | 1626 | 1665 | 1703 | 1736 | 1768 | 1796 | 1823 | I | |
| 153 | 158 | 163 | 168 | 172 | 177 | 182 | 187 | 192 | I/Y | |
| 23,9 | 24,9 | 25,8 | 26,8 | 27,7 | 28,7 | 29,6 | 30,6 | 31,5 | A | 120 |
| 1861 | 1915 | 1968 | 2020 | 2071 | 2120 | 2169 | 2215 | 2261 | I | |
| 171 | 177 | 182 | 188 | 193 | 199 | 204 | 210 | 215 | I/Y | |
| 25,1 | 26,1 | 27,1 | 28,1 | 29,0 | 30,0 | 31,0 | 32,0 | 33,0 | A | 130 |
| 2218 | 2282 | 2346 | 2401 | 2456 | 2511 | 2566 | 2621 | 2676 | I | |
| 190 | 197 | 203 | 209 | 214 | 220 | 226 | 232 | 238 | I/Y | |
| 26,3 | 27,3 | 28,3 | 29,4 | 30,4 | 31,4 | 32,4 | 33,5 | 34,5 | A | 140 |
| 2615 | 2685 | 2755 | 2825 | 2894 | 2963 | 3032 | 3100 | 3168 | I | |
| 209 | 216 | 223 | 230 | 236 | 243 | 249 | 256 | 262 | I/Y | |
| 27,5 | 28,6 | 29,7 | 30,8 | 31,8 | 32,9 | 33,9 | 35,0 | 36,0 | A | 150 |
| 3051 | 3139 | 3227 | 3304 | 3380 | 3452 | 3524 | 3591 | 3657 | I | |
| 230 | 238 | 246 | 253 | 259 | 266 | 273 | 280 | 287 | I/Y | |
| 31,1 | 32,4 | 33,6 | 34,8 | 36,0 | 37,2 | 38,4 | 39,6 | 40,8 | A | 180 |
| 4601 | 4736 | 4870 | 4984 | 5097 | 5207 | 5317 | 5422 | 5527 | I | |
| 295 | 306 | 316 | 325 | 334 | 343 | 352 | 361 | 370 | I/Y | |

# TABLE 56
(CONCLUDED)

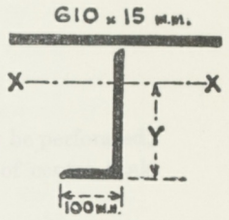
## GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of angle in square centimetres.
I = Moment of inertia about XX in centimetre units. } In conjunction with plating.
$I/_Y$ = Modulus of resistance of section in centimetre units. }

INVERTED ANGLES

| DEPTH OF WEB IN MILLIMETRES | ITEM | THICKNESS OF WEB IN MILLIMETRES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 8,0 | 8,5 | 9,0 | 9,5 | 10,0 | 10,5 | 11,0 | 11,5 | 12,0 |
| 100 | A | 15,5 | 16,4 | 17,3 | 18,3 | 19,2 | 20,1 | 20,9 | 21,8 | 22,7 |
| | I | 1008 | 1055 | 1102 | 1148 | 1193 | 1231 | 1269 | 1308 | 1346 |
| | $I/_Y$ | 105 | 111 | 116 | 122 | 127 | 132 | 137 | 142 | 147 |
| 120 | A | 17,3 | 18,2 | 19,2 | 20,1 | 21,1 | 22,1 | 23,1 | 24,1 | 25,1 |
| | I | 1548 | 1601 | 1654 | 1708 | 1762 | 1817 | 1872 | 1928 | 1984 |
| | $I/_Y$ | 136 | 142 | 148 | 154 | 160 | 166 | 172 | 178 | 184 |
| 130 | A | 18,1 | 19,2 | 20,2 | 21,2 | 22,1 | 23,3 | 24,4 | 25,4 | 26,3 |
| | I | 1797 | 1870 | 1942 | 2014 | 2085 | 2161 | 2237 | 2302 | 2367 |
| | $I/_Y$ | 148 | 155 | 162 | 169 | 176 | 184 | 191 | 198 | 204 |
| 140 | A | | | | | 23,2 | 24,3 | 25,3 | 26,4 | 27,5 |
| | I | | | | | 2455 | 2538 | 2621 | 2702 | 2782 |
| | $I/_Y$ | | | | | 194 | 202 | 209 | 217 | 225 |
| 150 | A | | | | | 24,2 | 25,4 | 26,5 | 27,6 | 28,7 |
| | I | | | | | 2863 | 2963 | 3063 | 3155 | 3246 |
| | $I/_Y$ | | | | | 213 | 222 | 230 | 239 | 247 |
| 160 | A | | | | | 25,2 | 26,4 | 27,6 | 28,8 | 29,9 |
| | I | | | | | 3368 | 3461 | 3554 | 3650 | 3746 |
| | $I/_Y$ | | | | | 239 | 246 | 253 | 261 | 269 |
| 170 | A | | | | | 26,2 | 27,5 | 28,7 | 29,9 | 31,1 |
| | I | | | | | 3776 | 3902 | 4028 | 4154 | 4280 |
| | $I/_Y$ | | | | | 251 | 261 | 271 | 281 | 291 |
| 200 | A | | | | | 29,2 | 30,6 | 32,0 | 33,4 | 34,8 |
| | I | | | | | 5466 | 5655 | 5844 | 6025 | 6206 |
| | $I/_Y$ | | | | | 314 | 327 | 340 | 353 | 366 |

# GEOMETRICAL PROPERTIES OF SECTIONS




## HAVING 100 mm. FLANGE

| THICKNESS OF WEB IN MILLIMETRES | | | | | | | | ITEM | DEPTH OF WEB IN MILLIMETRES |
|---|---|---|---|---|---|---|---|---|---|
| 12,5 | 13,0 | 13,5 | 14,0 | 14,5 | 15,0 | 15,5 | 16,0 | | |
| 23,6 | 24,5 | 25,4 | 26,2 | 27,1 | 27,9 | 28,8 | 29,6 | A | 100 |
| 1382 | 1417 | 1449 | 1481 | 1510 | 1539 | 1568 | 1596 | I | |
| 152 | 156 | 160 | 164 | 168 | 172 | 176 | 180 | $I/y$ | |
| 26,1 | 27,1 | 28,1 | 29,0 | 30,0 | 30,9 | 31,9 | 32,7 | A | 120 |
| 2041 | 2098 | 2149 | 2199 | 2248 | 2297 | 2345 | 2392 | I | |
| 190 | 196 | 202 | 208 | 214 | 220 | 226 | 232 | $I/y$ | |
| 27,5 | 28,6 | 29,5 | 30,4 | 31,4 | 32,4 | 33,4 | 34,4 | A | 130 |
| 2440 | 2512 | 2566 | 2619 | 2668 | 2716 | 2760 | 2803 | I | |
| 212 | 219 | 225 | 231 | 237 | 242 | 247 | 252 | $I/y$ | |
| 28,6 | 29,7 | 30,7 | 31,8 | 32,8 | 33,9 | 34,9 | 36,0 | A | 140 |
| 2861 | 2940 | 3017 | 3094 | 3169 | 3244 | 3317 | 3389 | I | |
| 233 | 240 | 247 | 254 | 261 | 267 | 273 | 279 | $I/y$ | |
| 29,9 | 31,0 | 32,1 | 33,2 | 34,3 | 35,4 | 36,5 | 37,6 | A | 150 |
| 3335 | 3424 | 3509 | 3594 | 3670 | 3746 | 3824 | 3902 | I | |
| 255 | 263 | 271 | 279 | 287 | 294 | 302 | 309 | $I/y$ | |
| 31,1 | 32,2 | 33,4 | 34,6 | 35,8 | 36,9 | 38,1 | 39,2 | A | 160 |
| 3845 | 3944 | 4047 | 4150 | 4242 | 4334 | 4422 | 4510 | I | |
| 278 | 286 | 296 | 305 | 314 | 322 | 330 | 338 | $I/y$ | |
| 32,4 | 33,6 | 34,8 | 36,0 | 37,2 | 38,4 | 39,6 | 40,8 | A | 170 |
| 4396 | 4512 | 4628 | 4743 | 4858 | 4973 | 5086 | 5198 | I | |
| 301 | 311 | 321 | 330 | 339 | 348 | 357 | 365 | $I/y$ | |
| 36,2 | 37,6 | 39,0 | 40,3 | 41,7 | 43,0 | 44,4 | 45,7 | A | 200 |
| 6382 | 6557 | 6708 | 6859 | 7018 | 7177 | 7326 | 7475 | I | |
| 379 | 391 | 403 | 414 | 426 | 438 | 449 | 460 | $I/y$ | |

# OIL TANKERS

## Section 40

### GENERAL

#### Application

**4001** The following Rules apply to the Class 100A1 Oil Tanker. (*See* B 103.) The scantlings and arrangements of tankers intended for cargoes other than petroleum will be specially considered in relation to the nature and density of the cargo.

Sections D 1 to D 33 apply to tankers except as otherwise required by the following Rules.

For scantling reductions when higher tensile steel complying with P 219 to P 227 is used, *see* D 65, D 66 and D 67.

#### Method of Construction

**4002** The following Rules and Tables give requirements for welded construction with certain modifications when riveting is adopted.

#### Structural Design

**4003** The Rules apply to single deck tankers of 91,5 metres in length and over with machinery aft and having two or more longitudinal bulkheads.

The bottom and deck are to be framed longitudinally in the cargo tank spaces; the Rules assume longitudinal framing at the sides and longitudinal bulkheads where the length of the ship exceeds 198 metres, but alternative designs will be considered.

If the proportion of length to depth exceeds fourteen or the ratio of breadth to depth exceeds 2,1, increased scantlings may be required.

**4004** The length of a tank is not to exceed 0,2L. When the length exceeds 0,1L or 15,25 metres, whichever is the greater, a transverse wash bulkhead is to be fitted at about the mid-length of the tank.

Where the distance between transverse bulkheads (whether oiltight or non-oiltight) exceeds 0,07L or 15,25 metres, whichever is the greater, additional transverse strengthening is to be fitted at about the mid-distance between the bulkheads. (*See* D 4604, D 4608, D 4613, D 5012 and D 5026.)

**4005** A centreline bulkhead, which may be perforated, is generally to be fitted when the breadth of centre tank exceeds

(a) 0,40B when the breadth B exceeds 38,10 metres,

(b) $\left(0{,}40+\frac{38{,}10-B}{30{,}5}\right)$ B when the breadth B exceeds 35,05 metres, but does not exceed 38,10 metres,

(c) 0,50B when the breadth B exceeds 33,55 metres, but does not exceed 35,05 metres,

(d) 19,05 metres irrespective of the breadth B.

**4006** Where, in ships having a breadth B exceeding 38,10 metres, only two longitudinal bulkheads are required by 4005 (a), the bottom and deck centreline girders and the side girders in the wing tanks are to be continuous and increased in depth.

**4007** Where the breadth B is between 33,55 metres and 38,10 metres and the breadth of the centre tank exceeds 0,40B but does not exceed the values given in 4005 (b) or (c) the continuous bottom and deck centreline girders are to be increased in depth.

They are also to be increased if the breadth of the centre tank exceeds 16,75 metres, irrespective of the breadth B, and no centreline bulkhead is required.

#### Loading

**4008** The Rules are framed on the understanding that the loading will be homogeneous over the full range of cargo tanks (unless certain tanks are intended to be dry or arranged for water ballast only) and with the ship in a reasonable service trim.

Any dry tanks, or tanks intended for water ballast only and thus empty in the loaded condition, are to be indicated on the plans submitted for approval and the arrangements are to be such that these tanks cannot be used for any other purpose.

**4009** Schemes of loading covering the normal cargo and ballast conditions are to be submitted for approval as early as possible; particulars of the light ship weight and weight of machinery are to be supplied.

In order to guard against high stresses being imposed through an unsatisfactory cargo or ballast loading it is recommended that tankers be supplied with an approved instrument for determining suitable loading.

**Quality of Material**

**4010** Where the thickness of plating exceeds 20,5 mm. and the seams and butts are welded, steel of grade D (*see* P 2, Table II) will generally be required for the following parts of the structure:—

(*a*) Sheerstrake, strength deck stringer and plating, top strake of the longitudinal bulkhead, deck longitudinals of the slab type where cut from plates and through brackets for deck longitudinals.

This grade D plating is to extend from 0,15L aft of amidships to 0,15L forward of amidships where the length is 152,4 metres and below, and from 0,2L aft of amidships to 0,2L forward of amidships where the length is 213,4 metres and above, with intermediate values obtained by interpolation, always provided that the forward limit extends at least 3 metres forward of the bridge front.

In addition, the sheerstrake and strength deck stringer and plating are to be of grade D in way of the poop front, extending forward to cover any pump room openings. Any stringer, deck or sheerstrake plating between the above after limit of the midship portion and 0,25L aft of amidships which is above 25,5 mm. in thickness should also be of grade D.

Any sheerstrake or stringer plate outside the above limits which exceeds 25,5 mm. in thickness should also be grade D.

Face flats of deck longitudinals or girders are to be of grade D if exceeding 35,5 mm. in thickness.

(*b*) Bottom shell plating to upper turn of bilge, bottom strake of the longitudinal bulkhead, bottom longitudinals of the slab type cut from plates and through brackets of bottom longitudinals.

This grade D plating is to extend from 0,15L aft of amidships to 0,15L forward of amidships where the length is 152,4 metres and below, and from 0,25L aft of amidships to 0,2L forward of amidships where the length is 213,4 metres and above with intermediate values obtained by interpolation.

In addition, the bottom plating between the above after limit and 0,25L aft of amidships is to be of grade D where the thickness is above 25,5 mm.

Where the bottom plating is required to be of steel of the above grade, the keel plate is also to be of the same grade.

Face flats of bottom longitudinals or girders are to be of grade D if exceeding 35,5 mm. in thickness.

**4011** Strakes of grade E steel are to be arranged as follows:—

| LENGTH L | | Grade E Strakes |
|---|---|---|
| Over | Not exceeding | |
| Metres 213,4 | Metres 228,6 | Bilge strake |
| 228,6 | 243,8 | Bilge strake<br>Sheerstrake |
| 243,8 | 259,1 | Bilge strake<br>Sheerstrake<br>Bottom strake in way of longitudinal bulkhead |
| 259,1 | | As for tankers over 243,8 metres with the addition of the keel<br>The deck strake in way of the longitudinal bulkhead is also to be grade E unless the top strake of the bulkhead is grade D |

The fore and aft extent of the grade E strakes is to be as follows:—

(a) Sheerstrake and deck plating from within the poop to 0,2L forward of amidships.

(b) Bottom and bilge plating from 0,25L aft of amidships to 0,2L forward of amidships.

The breadth of each strake is not to be less than 1525 mm. except that the bilge strake shall not be less than 1835 mm.

Any plates in the deck or bottom exceeding 35,5 mm. in thickness are to be grade E.

The use of riveted seams as an alternative to strakes of grade E steel will be specially considered.

**Cofferdams and Below Deck Passages or Tunnels**

**4012** Cofferdams are to be provided at the forward and after ends of the oil cargo spaces; cofferdams are to be at least 760 mm. in length and are to cover the whole area of the end bulkheads of the cargo spaces.

Pump rooms or water ballast tanks will be accepted in lieu of a cofferdam. An oil fuel bunker will also be accepted provided the bulkhead between it and the cargo tank is completely welded.

(The attention of the Owners should be drawn to the Suez Canal Authorities' requirement that only pump rooms or water ballast tanks can be accepted in lieu of a cofferdam.)

A cofferdam is also to be arranged between a cargo oil tank and accommodation spaces or between a cargo oil tank and spaces containing electrical equipment other than spaces where the only electrical equipment is lighting

fittings complying with M 1604. (*See also* M 1605.) Where the bridge 'tween deck acts as a cofferdam any access to this 'tween deck from the deck above is to be from the open deck.

Passages or tunnels passing through, or adjacent to, a cargo oil tank and not separated from it by a cofferdam are to be provided with mechanical ventilation, and any access is to be from the open deck.

### Superstructures

**4013** A forecastle of not less than 0,07L in length is to be fitted.

The machinery casings on the strength deck are to be protected by a poop or deckhouse of equivalent strength.

### Freeing Arrangements and Gangway

**4014** Ships with bulwarks are to have open rails fitted for at least half the length of the exposed part of each well.

A strong permanent fore and aft gangway is to be fitted at the level of the superstructure decks. Where there is no accommodation forward, the gangway between the bridge and forecastle may be omitted and where there is no midship erection and all accommodation, etc., is aft, the gangway may be omitted entirely. Arrangements are, however, to be made to give safe access to the fore end of the ship.

### Submission of Plans

**4015** In addition to the plans required by D 108, plans showing the construction of the transverse and longitudinal oiltight bulkheads, end connections for all longitudinals and other framing members, the structure at the ends of the ship, deckhouses protecting machinery casings and arrangements at the junction of transverse and longitudinal framing are also to be submitted.

A plan showing the arrangement and sequence of erection of the fabrication units is to be submitted.

**4016** The information required by D 4102 is to be forwarded when the midship section is submitted.

### Equipment

**4017** The equipment of anchors, chain cables, wires and ropes is to be as required by Table 53 and associated notes. The "Equipment Number" is to be determined in accordance with D 3303, except that for ships without sheer in way of 0,5L amidships the depth for calculating the Hull Number may be taken as 97 per cent of the depth moulded amidships.

### Anodes in Tanks

**4018** When anodes are fitted in tanks they are to be of approved design and securely attached to the structure, both initially and during service. A plan showing the details of design and attachment and the location of the anodes is to be submitted.

### Fittings in Tanks

**4019** Ladders, pipe hangers and other fittings in the cargo tanks and pump rooms are to be securely fastened to the structure.

### Corrosion Control

**4020** When an approved system of corrosion control is installed the reduction in thickness given below will be allowed. Where reductions are desired at the top of the tank within 1,525 metres of the deck at side, this part of the tank is to be coated but other approved systems may be used for the remainder of the tank.

When reductions have been effected a notation will be made in the Register Book.

| ITEM | PERMISSIBLE REDUCTION IN THICKNESS |
|---|---|
| Plating and stiffeners of transverse and longitudinal bulk heads.<br>Bottom, side and deck transverses.<br>Transverse side framing.<br>Vertical webs and horizontal girders.<br>Cross ties. | 10 per cent |
| Keel.<br>Bottom and side shell.<br>Deck plating.<br>Bottom, side and deck longitudinals.<br>Bottom and deck centreline and side girders. | 5 per cent |

The minimum thickness of keel, bottom and deck plating given in Table 62 may be reduced by 5 per cent. The minimum thickness of the remaining items may be 1,0 mm. less than the minimum given in D 5308 and D 5309.

Special consideration will be given to the extent of protection required in tankers intended solely for the carriage of crude oil.

The plans of midship section, profile and decks and shell expansion should indicate both the rule scantlings and the thicknesses proposed.

## Section 41

### LONGITUDINAL STRENGTH

**General**

**4101** The required areas of bottom shell and strength deck plating amidships are to be obtained from Table 62. The areas are related to a numeral N which is to be determined in accordance with 4103 below.

**Definitions**

**4102**

| | | |
|---|---|---|
| W | = moulded displacement at draught d (*See* below) | Metric Tons |
| L | = length of ship (*See* D 201) | Metres |
| d | = summer draught measured from top of keel | ,, |
| B | = moulded breadth | ,, |
| D | = moulded depth | ,, |
| m | = weight of main and auxiliary machinery and boilers in service condition, uptakes, generators, pumps, compressors, piping, flooring, gratings, ladders, stores, spare parts, loose tanks and fittings in the machinery compartment but excluding cargo pumps, propeller, shafting and funnel | Metric Tons |
| $C_b$ | = moulded block coefficient at draught equal to 0,06L | |
| $l$ | = total cargo tank length | Metres |
| $l_f$ | = cargo tank length forward of midships | ,, |
| $l_a$ | = cargo tank length aft of midships | ,, |
| $l^1$ | = equivalent* length of empty tank, cofferdam, pump room, etc., within length $l$ | ,, |
| x | = distance of centre of gravity of empty tank from amidships | ,, |

* Equivalent length is defined as $\frac{\text{"empty tank volume"}}{B \times D}$

An empty tank is a dry or water ballast tank as defined in D 4008.

**Effective Numeral**

**4103** The value of Numeral N to be used in Table 62 depends on the relative values of $N_1$ and $N_2$ (*See* 4104 and 4105) and

If $N_1$ is greater than $N_2$ then $N = N_1$

If $N_2$ is greater than $N_1$ then $N = \frac{N_1 + 2N_2}{3}$

If $N_2$ is negative, special consideration will be given to the scantlings required.

**Determination of $N_1$**

**4104** The numeral $N_1$ is given by

$$N_1 = K\ B\ (C_b + 0{,}70)$$

The value of K is found from Table 60.

Where the block coefficient (at a draught of 0,06L) is less than 0,75 the scantlings will be specially considered.

**Determination of $N_2$**

**4105** $N_2$ is to be calculated as follows:—

$$N_2 = \frac{e\ W\ L}{538{,}74 \times 10^4}$$

The value of e is given by the algebraic sum of the following basic value and corrections:—

Basic value of $e = 125 - \frac{304{,}800}{W}$

1st correction $= -\frac{m}{W}\ (1000 + 24P)$ (*See also* note 4 below)

2nd correction $= 18\ (P - 4)$

3rd correction $= 700\ (C_b - 0{,}80)$

4th correction $= 1530\ (\frac{d}{L} - 0{,}053)$

5th correction $=$

$$-3830\frac{l^1}{l}(0{,}1784 - 0{,}0046P - \frac{x}{L})\ (1 + \frac{l^1}{l})$$

The value of P is found from Table 61.

NOTES.— 1 $\frac{d}{L}$ and $\frac{x}{L}$ should be worked to four significant figures.

2 Corrections for each empty compartment must be made separately and where an empty compartment covers amidships the portions forward and aft of amidships are to be treated as two separate compartments.

3 The formulæ are applicable to ships having no sheer over 0,5L amidships. Ships with sheer extending an unusual distance into 0,5L amidships, or with an abnormal sheer at ends, will require special consideration.

4 Where there is no amidship erection other than a pump room casing and all accommodation is in the poop, the ratio of the machinery weight, m/W, in the first correction is to be increased by 0,006. This correction then becomes:—

$$-\left(\frac{m}{W} + 0{,}006\right)\ (1000 + 24P)$$

**4106** As an alternative to the calculation of $N_2$ in accordance with 4105 a detailed calculation of the still water bending moment may be carried out using an electronic computer. Particulars of the proposed computer programme are to be submitted, together with the method to be used for obtaining the assumed hull weight and its distribution. The

## TABLE 60 VALUES OF K

| LENGTH L | K | Difference in K per 5 metres difference in L | LENGTH L | K | Difference in K per 5 metres difference in L | LENGTH L | K | Difference in K per 5 metres difference in L |
|---|---|---|---|---|---|---|---|---|
| Metres | | | Metres | | | Metres | | |
| 90 | 0,788 | | 165 | 2,950 | 0,198 | 240 | 7,025 | 0,335 |
| | | 0,106 | | | 0,207 | | | 0,344 |
| 95 | 0,894 | | 170 | 3,157 | | 245 | 7,369 | |
| | | 0,109 | | | 0,215 | | | 0,354 |
| 100 | 1,003 | | 175 | 3,372 | | 250 | 7,723 | |
| | | 0,112 | | | 0,224 | | | 0,363 |
| 105 | 1,115 | | 180 | 3,596 | | 255 | 8,086 | |
| | | 0,116 | | | 0,234 | | | 0,372 |
| 110 | 1,231 | | 185 | 3,830 | | 260 | 8,458 | |
| | | 0,120 | | | 0,244 | | | 0,381 |
| 115 | 1,351 | | 190 | 4,074 | | 265 | 8,839 | |
| | | 0,125 | | | 0,255 | | | 0,390 |
| 120 | 1,476 | | 195 | 4,329 | | 270 | 9,229 | |
| | | 0,130 | | | 0,265 | | | 0,399 |
| 125 | 1,606 | | 200 | 4,594 | | 275 | 9,628 | |
| | | 0,138 | | | 0,274 | | | 0,408 |
| 130 | 1,744 | | 205 | 4,868 | | 280 | 10,036 | |
| | | 0,147 | | | 0,282 | | | 0,417 |
| 135 | 1,891 | | 210 | 5,150 | | 285 | 10,453 | |
| | | 0,155 | | | 0,290 | | | 0,426 |
| 140 | 2,046 | | 215 | 5,440 | | 290 | 10,879 | |
| | | 0,164 | | | 0,299 | | | 0,435 |
| 145 | 2,210 | | 220 | 5,739 | | 295 | 11,314 | |
| | | 0,172 | | | 0,308 | | | 0,444 |
| 150 | 2,382 | | 225 | 6,047 | | 300 | 11,758 | |
| | | 0,181 | | | 0,317 | | | 0,454 |
| 155 | 2,563 | | 230 | 6,364 | | 305 | 12,212 | |
| | | 0,189 | | | 0,326 | | | |
| 160 | 2,752 | | 235 | 6,690 | | | | |
| | | 0,198 | | | 0,335 | | | |

departure and arrival conditions are to include the amounts of oil fuel, etc., given below:—

| | Departure | Arrival |
|---|---|---|
| Oil Fuel (Diesel) | 0·04 W | 0·02 W |
| ,, ,, (Turbine) | 0·06 W | 0·02 W |
| Fresh Water | 0·01 W | 0·0025 W |
| Stores | 0·009 W | 0·003 W |

The value of $N_2$ is to be taken as:—

$$N_2 = \frac{\text{Still water bending moment in arrival condition}}{511{,}81}$$

**Determination of Bottom and Deck Areas**

**4107** The required bottom and deck areas corresponding to the effective Numeral N are to be obtained from Table 62 and Notes. The area derived from the Table and corrected as required by Note (1) is the bottom area. The deck area is to be 90 per cent of the corrected bottom area.

## Section 42

### DECKS

**Strength Deck**

**4201** The thickness of deck plating derived in accordance with D 41 is to be maintained from 0,25L aft of amidships to 0,2L forward of amidships and is to be gradually tapered to the end thickness.

**4202** The thickness at the poop front is to extend into the poop for a distance at least equal to one-third the breadth B.

Where the machinery opening extends forward beyond a point one-third of the breadth B abaft the poop front, and the width of the casing exceeds one-half the breadth of the ship at the poop front, the thickness of deck plating may require to be increased. The forward corners of the casing opening are to be well rounded.

**4203** The thickness of the stringer plate at the ends of the bridge is to be increased by 20 per cent.

If the poop front extends within 0,25L from amidships the stringer plate at the break is to be increased by 20 per cent. No increase is required if the poop front is 0,3L from amidships or greater. The increase at intermediate lengths is to be obtained by interpolation and is to be applied to the tapered thickness of the stringer plate.

The increase in thickness need not exceed 5 mm.

**4204** The thickness of the deck stringer and plating for 0,05L at ends is not to be less than $\left(6{,}1+\frac{L}{48}\right)$ mm.

**4205** If a stringer angle is fitted, in way of the cargo tanks and for at least one-third of the breadth B within the poop it is to have 150 mm. flanges when the length L does not exceed 137 metres, 180 mm. flanges for lengths exceeding 137 metres and not exceeding 167,5 metres and 200 mm. flanges above 167,5 metres. The thickness is to be that of the sheerstrake or stringer whichever is less. Alternative riveted connections will be specially considered.

At the ends of the ship the scantlings of stringer angle are to be determined from Table 19.

If the stringer angle is cut at the scuppers, compensation is to be provided. (*See also* D 4308).

**4206** Where a rounded sheerstrake is incorporated the radius should, in general, not be less than 15 times the thickness. The radius should be made by careful cold rolling or bending. Where grade E plates are subjected to severe cold working or where local heating of the plates is adopted, the plates may require to be re-normalised.

**4207** The corners of all deck openings are to be well rounded and smooth, and strength is to be maintained in way of pump room entrances or other openings but compensation will not, in general, be required for small elliptical

## TABLE 61 VALUES OF P

| $\frac{l}{L}$ | $\frac{l_f}{l_a}$ = 1,1 | Differences | $\frac{l_f}{l_a}$ = 1,2 | Differences | $\frac{l_f}{l_a}$ = 1,3 | Differences | $\frac{l_f}{l_a}$ = 1,4 | Differences | $\frac{l_f}{l_a}$ = 1,5 | Differences | $\frac{l_f}{l_a}$ = 1,6 | Differences | $\frac{l_f}{l_a}$ = 1,7 | $\frac{l}{L}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **0,56** | **8,45** | 0,17 | **8,28** | 0,26 | **8,02** | 0,29 | **7,73** | 0,33 | **7,40** | 0,39 | **7,01** | 0,42 | **6,59** | **0,56** |
| | | 1,04 1,04 | | 1,04 1,04 | | 1,04 1,04 | | 1,04 1,05 | | 1,05 1,06 | | 1,06 1,07 | | |
| **0,58** | **7,41** | 0,17 | **7,24** | 0,26 | **6,98** | 0,29 | **6,69** | 0,34 | **6,35** | 0,40 | **5,95** | 0,43 | **5,52** | **0,58** |
| | | 1,01 1,02 | | 1,02 1,02 | | 1,02 1,03 | | 1,03 1,03 | | 1,03 1,03 | | 1,03 1,02 | | |
| **0,60** | **6,40** | 0,18 | **6,22** | 0,26 | **5,96** | 0,30 | **5,66** | 0,34 | **5,32** | 0,40 | **4,92** | 0,42 | **4,50** | **0,60** |
| | | 0,99 1,00 | | 1,00 1,00 | | 1,00 1,00 | | 1,00 1,00 | | 1,00 0,99 | | 0,99 0,98 | | |
| **0,62** | **5,41** | 0,19 | **5,22** | 0,26 | **4,96** | 0,30 | **4,66** | 0,34 | **4,32** | 0,39 | **3,93** | 0,41 | **3,52** | **0,62** |
| | | 0,97 0,98 | | 0,98 0,97 | | 0,97 0,96 | | 0,96 0,95 | | 0,95 0,94 | | 0,94 0,92 | | |
| **0,64** | **4,44** | 0,20 | **4,24** | 0,25 | **3,99** | 0,29 | **3,70** | 0,33 | **3,37** | 0,38 | **2,99** | 0,39 | **2,60** | **0,64** |
| | | 0,94 0,94 | | 0,94 0,94 | | 0,94 0,93 | | 0,93 0,92 | | 0,92 0,90 | | 0,90 0,87 | | |
| **0,66** | **3,50** | 0,20 | **3,30** | 0,25 | **3,05** | 0,28 | **2,77** | 0,32 | **2,45** | 0,36 | **2,09** | 0,36 | **1,73** | **0,66** |
| | | 0,91 0,91 | | 0,91 0,90 | | 0,90 0,89 | | 0,89 0,87 | | 0,87 0,85 | | 0,85 0,83 | | |
| **0,68** | **2,59** | 0,20 | **2,39** | 0,24 | **2,15** | 0,27 | **1,88** | 0,30 | **1,58** | 0,34 | **1,24** | 0,34 | **0,90** | **0,68** |
| | | 0,90 0,90 | | 0,90 0,89 | | 0,89 0,88 | | 0,88 0,86 | | 0,86 0,84 | | 0,84 0,82 | | |
| **0,70** | **1,69** | 0,20 | **1,49** | 0,23 | **1,26** | 0,26 | **1,00** | 0,28 | **0,72** | 0,32 | **0,40** | 0,32 | **0,08** | **0,70** |

**NOTE.—TABLE 61**

The values of P in the above Table correspond to a standard $C_b$ of 0,80 and where the $C_b$ differs from 0,80 the Table value is to be corrected as follows:—

$$P = \text{Table value} - 150\left(\frac{l}{L} - 0{,}64\right)\left(C_b - 0{,}80\right).$$

| N | BASIC AREA | BASIC DEPTH $D_1$ | DEPTH CORRECTION | MINIMUM BOTTOM THICKNESS | MINIMUM KEEL THICKNESS |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| | Sq. cm. | Metres | Sq. cm. | mm. | mm. |
| **10** | 870 | 5,70 | 130 | 10 | 14 |
| **20** | 1305 | 7,30 | 150 | 11,5 | 16,5 |
| **30** | 1665 | 8,50 | 170 | 12,5 | 18 |
| **40** | 2000 | 9,45 | 185 | 14 | 19 |
| **60** | 2590 | 10,75 | 210 | 16 | 21 |
| **80** | 3145 | 11,80 | 225 | 17,5 | 22 |
| **100** | 3675 | 12,55 | 255 | 19 | 23,5 |
| **140** | 4665 | 13,75 | 295 | 21,5 | 25 |
| **180** | 5585 | 14,70 | 330 | 23 | 26,5 |
| **230** | 6700 | 15,65 | 370 | 25,5 | 28 |
| **290** | 8010 | 16,65 | 410 | 27,5 | 28,5 |
| **370** | 9630 | 17,85 | 470 | 29,5 | 29,5 |
| **470** | 11540 | 19,00 | 530 | 31,5 | 31,5 |
| **570** | 13420 | 19,95 | 590 | 32,5 | 32,5 |
| **710** | 15860 | 21,20 | 675 | 33,5 | 33,5 |
| **850** | 18280 | 22,10 | 750 | 34 | 34 |

**NOTES.—TABLE 62**

1. Where the depth D is $\frac{\text{greater}}{\text{less}}$ than the basic depth $D_1$ the tabular bottom area is to be $\frac{\text{reduced}}{\text{increased}}$ at the rate per metre of difference given in column 4.

2. The bottom area is that for one side of the ship and includes the following items up to 0,1D from the base line:—

One half the keel plate
Bottom and bilge plating
Bottom, bilge and side longitudinals
One half the centre girder
Side girders
Plating and longitudinal stiffeners of longitudinal bulkheads (including one half of a centre line bulkhead)

3. The deck area is that for one side of the ship in way of openings and includes the following items down to 0,1D from the deck line at side:—

Deck stringer and plating
Sheerstrake
Stringer angle (if fitted)
Deck and side longitudinals
One half the centre line deck girder
Side girders
Plating and longitudinal stiffeners of longitudinal bulkheads (including one half of a centre line bulkhead)

4. Elliptical deck openings need not be deducted provided their major axes are fore and aft, the ratio of the length to breadth of each opening is not less than 2 and the total breadth of such openings in a transverse section does not exceed 0,06B. Lightening holes in girders need not be deducted provided their depth does not exceed 20 per cent of the depth of the girder web.

Where longitudinals are scalloped the net area in way of scallop is to be used. Isolated drain holes need not be deducted, but compensation will be required for large drain holes at the bulkheads.

5. The thickness of bottom plating given in column 5 is in association with a spacing of longitudinals of 890 mm. at 122 metres and below or 1015 mm. at 274,5 metres and above with intermediate values in proportion.

Where the spacing of longitudinals differs from the above, the minimum thickness is to be increased or reduced at the rate of $1\frac{1}{2}$ per cent for every 25 mm. difference.

6. The thickness of deck plating is not to be less than 80 per cent of that given in column 5 and is not, in general, to be corrected for longitudinal spacing.

7. For permissible reductions when an approved system of corrosion control is fitted *see* D 4020.

openings (*see* Note 4 to Table 62) nor forward of 0,2L forward of amidships nor abaft the poop front bulkhead. It is recommended that compensation for deck openings should be in the form of an increased thickness of plating, but alternative methods will be specially considered.

**Lower Decks**

**4208** The scantlings and arrangements of lower decks are to be as required by D 11, D 14 and D 15.

**4209** Abrupt discontinuities at the ends of lower decks and flats are to be avoided by suitable tapering of the stringer plates or by fitting large brackets.

## Section 43

### SHELL PLATING

**Bottom Shell and Keel**

**4301** The thickness of bottom shell plating derived in accordance with D 41 is to be determined from 0,25L aft of amidships to 0,2L forward of amidships and is to be gradually tapered to the end thickness. (*See* 4305).

**4302** The width of the keel is to be not less than 70B mm. (where B is the moulded breadth) but need not exceed 1830 mm. The thickness may be as given in D 4107 Table 62, but is not to be less than the bottom shell.

The width and thickness given above are to be maintained throughout.

**Side Shell**

**4303** Within 0,25L forward and 0,25L aft of amidships the thickness of side shell is not to be less than $\frac{3,66}{10^7}$ (L+1219) (d+9,14) (s+1016) mm. where L and d are as defined in D 4102 and s is the spacing of side longitudinals or side framing (as appropriate) in mm. In no case is the value of s used in this formula to be less than (559+1,11L) mm.

**4304** The midship thickness of side shell is to be gradually tapered to the end thickness. (*See* 4305).

**End Thickness**

**4305** The thickness of shell plating for 0,05L from ends is not to be less than $\left(6,4+\frac{L}{30}\right)$ mm.

**Sheerstrake**

**4306** The width of sheerstrake from 0,25L aft of amidships to 0,2L forward of amidships is not to be less than 150D mm. but need not exceed 2135 mm. and the thickness is not to be less than that of the deck plating or side shell, whichever is the greater.

At ends the thickness of sheerstrake may be the same as the side shell.

**4307** The thickness of the sheerstrake is to be increased 20 per cent at the ends of the bridge, but this increase is not required if the bridge does not extend to the ship's side.

If the poop front at side extends within 0,25L from amidships the sheerstrake at the break is to be increased by 20 per cent. No increase is required if the poop front at side is 0,3L from amidships or greater. The increase at intermediate positions is to be obtained by interpolation and is to be applied to the tapered thickness of the sheerstrake.

**4308** The upper edge of the sheerstrake is to be dressed smooth and kept free of isolated welded fittings or connections. In ships over 183 metres in length scupper openings are not to be cut above the deck.

Where a rounded sheerstrake is adopted, the welding of fairleads or other fittings to this plate is to be reduced to a minimum and details are to be submitted for approval.

**Openings in Shell**

**4309** Sea inlets in pump rooms situated within 0,5L amidships, are, if practicable, to be fitted clear of the bilge radius. All openings are to be arranged so as to minimise discontinuity of transverse frames, longitudinals or bilge keels. Compensation is to be provided for all openings within 0,5L amidships and may be required for openings in the vicinity of the poop front. The compensation should, if possible, take the form of an insert plate rather than a doubler.

If openings are not circular or oval the corners are to be rounded with as large a radius as practicable.

**Bilge Keels**

**4310** Where bilge keels are fitted, it is desirable that they be attached to a continuous flat bar which may be welded to the shell. Scallops are to be arranged in way of welded butts in the flat bar. Alternative arrangements, or arrangements omitting the flat bar, will be specially considered.

Bilge keels are to be gradually tapered at their ends and are not to finish on an unstiffened panel.

## Section 44

### BOTTOM, SIDE AND DECK LONGITUDINALS

**Scantlings**

**4401** The scantlings of longitudinals within the range of cargo tanks are not to be less than required by the following formulæ:—

Bottom longitudinals $\frac{I}{y} = \frac{s \times S^2 \times D}{65,85}$ cm.$^3$

Deck longitudinals $\frac{I}{y} = \frac{s \times S^2}{100}\left\{1,85 + \left(\frac{L}{109,7}\right)^3\right\}$ cm.$^3$

Side longitudinals $\frac{I}{y} = \frac{s \times S^2}{118}\left(h + \frac{D}{6}\right)$ cm.$^3$

Where s = spacing of longitudinals in mm.

S = span in metres measured between transverses or from transverse to "span point" (minimum value 2,44 metres),

L = length of ship in metres,

h = distance of longitudinal below deck at side in metres,

D = moulded depth in metres.

The section modulus given by these formulæ is that of the longitudinal and associated plating. (*See* D 5301.)

The scantlings derived from the above, using the midship thickness of plating, are to extend throughout the cargo tanks.

**4402** The scantlings of bilge longitudinals are to be graduated between those required for the bottom and lowest side longitudinals.

**4403** Where flat bars are used for longitudinals and these are continuous at bulkheads, the thickness is not to be less than one-eighteenth of the depth; otherwise the thickness should not be less than one-fifteenth of the depth.

**Connections**

**4404** End connections of longitudinals to bulkheads are to provide adequate fixity and, so far as practicable, direct continuity of longitudinal strength.

**4405** Where the length exceeds 213,5 metres it is desirable that the bottom and deck longitudinals be continuous through the transverse bulkheads but alternative arrangements will be specially considered.

**4406** Longitudinals are to be connected to the transverses as required by Table 63E. In ships above 198 metres all longitudinals (including those on longitudinal bulkheads) are to have the web attached to the transverses. In ships between 152,5 and 198 metres, similar arrangements are to be made except that side longitudinals and longitudinal bulkhead horizontal stiffeners need not have the webs attached unless they are within 3 metres of the bottom or deck.

## Section 45

### TRANSVERSE SIDE FRAMING

**Scantlings**

**4501** Where, in tankers not exceeding 198 metres in length, transverse side framing is adopted in the cargo tanks, the section modulus of side frames is not to be less than:—

$\frac{I}{y} = \frac{s \times h \times S^2}{97,5}$ cm.$^3$ where side transverses are fitted,

or $\frac{I}{y} = \frac{s \times h \times S^2}{83,3}$ cm.$^3$ where side transverses are not fitted.

where s = frame spacing in mm.,

h = head in metres from mid-point of span to deck at side measured at mid-length of tank,

S = span in metres measured between stringers or from stringer to "span point".

The size of the frame is to be governed by the maximum modulus derived from the above formula and is to be maintained for the full depth of the ship. The modulus given is that of the frame and associated side shell plating. (*See* D 5301.)

**Side Stringers**

**4502** Where the depth D does not exceed 7,6 metres, one side stringer is to be fitted. Where D exceeds 7,6 metres but does not exceed 10,7 metres, 2 stringers are required and over 10,7 metres depth, 3 stringers. For scantlings of stringers *see* D 4702.

**Side Transverses**

**4503** Where the depth D exceeds 10,7 metres, or the distance between transverse bulkheads (whether oiltight or non-oiltight) exceeds 15,25 metres, side transverses are to be fitted in line with the bottom transverses. The scantlings of the side transverses are to be determined in accordance with D 4607 and D4608.

**Connections and End Attachments**

**4504** Side frames are to be connected to the side stringers as required by Table 63E.

**4505** The brackets at the upper end of side frames are to be as shown in Table 63F.

**4506** Side frames are to be efficiently connected at the lower end to stiffened brackets covering the entire round of bilge and extending at least to the first bottom longitudinal. The thickness of the bracket is to be the same as that of the transverses in the wing tank.

## Section 46

### BOTTOM, SIDE AND DECK TRANSVERSES

#### General

**4601** The spacing of transverse is generally not to exceed 3,66 metres when the length L is 183 metres or less, or 4,88 metres when L is 244 metres or over with spacings at intermediate lengths in proportion. Where, however, the longitudinal bulkhead is corrugated, the spacing of transverses is generally not to exceed 4,27 metres.

#### Bottom Transverses

**4602** The section modulus of the transverses is not to be less than:—

$\frac{I}{y} = 96{,}45\ s \times D\ (S-1{,}524)\text{cm.}^3$ where the span does not exceed 10 metres,

or $\frac{I}{y} = 8{,}15 \times s \times D \times S^2\ \text{cm.}^3$ where the span exceeds 10 metres,

where s = spacing of transverses, in metres,

S = span of transverses in metres from "span point" to "span point" (minimum value 2,75 metres),

D = moulded depth, in metres.

Where the bottom centre line girder is intercostal between the transverses the modulus derived as above is to be increased by 10 per cent.

**4603** If intercostal side girders are fitted, and their scantlings are in accordance with D 4809, the modulus of the bottom transverses derived in accordance with either of the preceding formulæ may be reduced by 5 per cent.

**4604** Where the distance between transverse bulkheads (whether oiltight or non-oiltight) exceeds 0,07L or 15,25 metres, whichever is the greater, the section modulus of the bottom transverse at about the mid-distance is to be increased at the rate of 25 per cent for each 1 per cent of the length L by which the distance exceeds 0,07L or 15,25 metres.

**4605** The depth of the bottom transverse is not to be less than either one-fifth of its span or $2\frac{1}{2}$ times the depth of the slot for the bottom longitudinal, whichever is the greater.

**4606** For minimum thicknesses *see* D 5308 and D 5309. For moduli of transverses of various depths, face areas and thicknesses of shell plating *see* D 5305.

#### Side Transverses

**4607** The section modulus of side transverses not supported by cross ties is not to be less than:—

$\frac{I}{y} = 148{,}4\ s \times h\ (S-1{,}524)\ \text{cm.}^3$ where the span does not exceed 10 metres,

or $\frac{I}{y} = 12{,}65\ s \times h \times S^2\ \text{cm.}^3$ where the span exceeds 10 metres.

Side tranverses supported by cross ties are to have a section modulus not less than that given by the following formulæ:—

| Number of Cross Ties | Section Modulus Cm.³ |
|---|---|
| 1 | $72{,}35\ s\ [(D-7{,}315)^2+7{,}25]$ |
| 2 | $57{,}8\ s\ [(D-7{,}315)^2+7{,}25]$ |
| 3 | $48{,}2\ s\ [(D-7{,}315)^2+7{,}25]$ |
| 4 | $42{,}8\ s\ [(D-7{,}315)^2+7{,}25]$ |
| 1 horizontal and 2 diagonal meeting at side transverse | $64{,}3\ s\ [(D-7{,}315)^2+7{,}25]$ |

In the above

s = spacing of transverse in metres,

h = head from mid-point of span to deck at side, in metres,

S = span of transverse in metres from "span point" to "span point",

D = moulded depth in metres.

**4608** Where the distance between transverse bulkheads (whether oiltight or non-oiltight) exceeds 0,07L or 15,25 metres, whichever is the greater, the section modulus of the side transverse at about mid-distance is to be increased at the rate of 25 per cent for each 1 per cent of the length L by which the distance exceeds 0,07L or 15,25 metres.

**4609** If side transverses are tapered, the increase in depth at the bottom, and decrease at the top, is not to exceed 10 per cent of the mean depth.

**4610** For minimum thicknesses *see* D 5308 and D 5309. For moduli of transverses of various depths, face areas and thicknesses of shell plating *see* D 5305.

#### Deck Transverses

**4611** The section modulus of deck transverses is not to be less than that given by the formula

$\frac{I}{y} = 53{,}75\ (0{,}0269\ s \times L+0{,}8)\ (S+1{,}83)\ \text{cm.}^3$

where s = spacing of transverses in metres,

L = length of ship in metres,
S = span of transverse in metres from "span point" to "span point".

**4612** If intercostal side girders are fitted, and their scantlings are in accordance with D 4814, the modulus of the deck transverses derived in accordance with the above formula may be reduced by 5 per cent.

**4613** Where the distance between transverse bulkheads (whether oiltight or non-oiltight) exceeds 0,07L or 15,25 metres, whichever is the greater, the section modulus of the deck transverse at about mid-distance is to be increased at the rate of 25 per cent for each 1 per cent of the length L by which the distance exceeds 0,07L or 15,25 metres.

**4614** The depth of the deck transverse is not to be less than one sixth of its span or $2\frac{1}{2}$ times the depth of the slot for the deck longitudinal, whichever is the greater.

**4615** For minimum thicknesses *see* D 5308 and D 5309.

For moduli of transverses of various depths, face areas and thicknesses of deck plating *see* D 5305.

## Section 47

### SIDE STRINGERS

**General**

**4701** Where transverse side framing is adopted, side stringers are to be fitted as required by D 4502.

**Scantlings**

**4702** The modulus of side stringers is not to be less than given by the following formulæ:—

| Position of Stringer | Section Modulus Cm.$^3$ |
|---|---|
| Single ... ... ... ... | $13{,}55\ b \times h \times S^2$ |
| Upper of two or more ... ... | $17{,}25\ b \times h \times S^2$ |
| Middle or lower ... ... ... | $13{,}55\ b \times h \times S^2$ |

where b = width of plating supported, in metres. Where applicable, the width supported is to be taken as half the distance from the next stringer to the deck at side or base line as appropriate.
h = head from stringer to highest point of tank, excluding hatchway, in metres,
S = span from "span point" to "span point" or from "span point" to side transverse, in metres (minimum value to be taken as 3 metres).

**4703** The depth of the stringer is not to be less than $2\frac{1}{2}$ times the depth of the slot for the frame.

**4704** Where side transverses are not fitted the lower side stringers are to be supported by suitable buttress brackets from the bottom transverses.

**4705** For minimum thicknesses *see* D 5308 and D 5309.

For moduli of transverses of various depths, face areas and thicknesses of shell plating *see* D 5305.

## Section 48

### BOTTOM AND DECK GIRDERS

**Bottom Centre Line Girder**

**4801** When the length L exceeds 167,5 metres and a centre line bulkhead is not fitted, the bottom transverses are to be supported by a centre line girder continuous between transverse bulkheads. The section modulus of the girder is not to be less than:—

$$\frac{I}{y} = 92{,}6\ b\ D\ (S - 0{,}61) \text{ centimetres}^3$$

where the span does not exceed 12,2 metres,

or $$\frac{I}{y} = 7{,}2\ b\ D\ S^2 \text{ centimetres}^3$$

where the span exceeds 12,2 metres.

where b = half breadth of centre tank, in metres, or, where there is a vertical web on the inboard side of the longitudinal bulkheads, half the distance between the faces of the webs,
D = moulded depth, in metres,
S = distance in metres from "span point" to "span point".

**4802** Where intercostal side girders, having scantlings as required by 4809, are fitted in the centre tank, the section modulus of the centre girder derived in accordance with 4801 may be reduced by 5 per cent.

**4803** Where the length L does not exceed 167,5 metres the centre line girder may be continuous between transverse bulkheads and have scantlings as required by 4801 or may be intercostal between transverses and effectively connected to the transverse and bulkheads. An intercostal girder is to have a section modulus not less than:—

$$\frac{I}{y} = 14{,}5\ B \times D \times s \text{ cm.}^3,$$

where B = moulded breadth, in metres,
D = moulded depth, in metres,
s = spacing of transverses, in metres.

**4804** The depth of an intercostal girder is not to exceed the depth of the transverses.

**4805** Vertical webs are generally to be arranged on the transverse bulkheads in association with continuous or intercostal bottom centre line girders.

**4806** Flanged or otherwise stiffened brackets are to be fitted on both sides of the girder mid-way between the transverses with intermediate vertical stiffeners not more than 990 mm. apart. The brackets are to be connected to a suitable bottom longitudinal. In deep centre line girders horizontal stiffening is to be arranged and the brackets on one side may stop at a suitable horizontal stiffener. The intermediate vertical stiffeners may be omitted but where the spacing of brackets exceeds 1830 mm. an intermediate vertical stiffener is to be fitted to the lower part of the girder.

**4807** The thickness of the centre girder is not to be less than 10 per cent thicker than that given in D 5309 unless suitable horizontal stiffening is arranged.

**Bottom Side Girders**

**4808** Continuous or intercostal side girders are generally to be arranged in the centre and wing tanks in ships exceeding 213,5 metres or where the distance between transverse bulkheads (whether oiltight or non-oiltight) exceeds 16,75 metres. The girders are to be arranged in line with vertical webs on the transverse bulkheads and below the deck to form a ring system.

**4809** The section modulus is not to be less than:—

$$\frac{I}{y} = 19\ S^2 \times b_1 \times D\ \text{cm.}^3,$$

where S = span measured from transverse to transverse, in metres,

$b_1$ = half breadth of centre tank (or breadth of wing tank) in metres divided by the number of side girders plus one. (The number of side girders is to be that in the half breadth of centre tank or breadth of wing tank as appropriate),

D = moulded depth, in metres.

**4810** The depth of the side girder is not to be less than 50 per cent of the depth of the bottom transverse and is to be efficiently bracketed thereto.

**4811** For reduction to modulus of centre girder and bottom transverses when side girders are fitted in accordance with 4809, *see* 4802 and D 4603.

**Deck Centre Line Girder**

**4812** A continuous deck centre line girder is to be fitted having a section modulus not less than:—

$$\frac{I}{y} = \frac{l^2 \times b \times L}{10,5}\ \text{cm.}^3,$$

where $l$ = length of centre tank, in metres,

b = half-breadth of centre tank, in metres, or, where there is a vertical web on the inboard side of the longitudinal bulkheads, half the distance between the faces of the webs,

L = length of ship, in metres.

**4813** Where intercostal side girders, having scantlings as required by 4814, are fitted in the centre tank the section modulus of the deck centre girder derived in accordance with 4812 may be reduced by 5 per cent.

**Deck Side Girders**

**4814** Side girders as required by 4808 are to have a depth not less than 50 per cent of the depth of the deck transverse. The face area is not to be less than that of the transverses.

**4815** For reduction to modulus of deck centre girder and deck transverses when side girders are fitted, *see* 4813 and D 4612.

**General**

**4816** For minimum thicknesses, *see* D 5308 and D 5309.

For moduli of girders of various depths, face areas and thicknesses of shell or deck plating, *see* D 5305.

## Section 49

### CROSS TIES

**4901** Cross ties may be of plate or sectional material and are to have an area and least moment of inertia not less than:—

$$A = 64 + 1,035\ l \times h \times s\ \text{cm.}^2,$$

$$I = 2,45\ l \times h \times s \times S^2\ \text{cm.}^4,$$

where $l$ = one half the distance in metres between the centre of the adjacent cross ties or between the centre of the adjacent cross tie and the centre of the bottom or deck transverse,

h = vertical distance in metres from the centre of the cross tie to deck at side amidships,

s = spacing of transverses, in metres,

S = length of cross tie in metres between the toes of the horizontal tripping brackets on the transverse webs at the cross ties. Special consideration will be given where alternative arrangements omitting the tripping brackets are provided.

Diagonal cross ties will be specially considered but, in general, the area and least moment of inertia of the horizontal cross tie is not to be less than 85 per cent of that required by the above formula assuming the centre cross tie only is

fitted. The area of each diagonal cross tie is not to be less than 85 per cent of that required for the horizontal cross tie.

**4902** Cross ties are to be connected to the vertical transverses or horizontal girders by suitable brackets. Tripping brackets are to be fitted to the transverses in way of the cross ties and where scallops for longitudinals or frames come in way of the cross ties they are to be closed by plate collars.

**4903** Cross ties are to be provided with suitable horizontal stiffening to prevent buckling and twisting. Where the unsupported width of face plate exceeds 150 mm., additional vertical stiffening is to be arranged to support the face plate.

## Section 50

### OILTIGHT AND NON-OILTIGHT BULKHEADS

### OILTIGHT BULKHEADS

#### General

**5001** Longitudinal bulkheads, other than at the centre line, are to be oiltight throughout the cargo tanks and may be plane or horizontally corrugated.

Where a centre line bulkhead is required by D 4005 it may be oiltight or perforated.

Longitudinal bulkheads may be perforated in pump rooms or cofferdams, provided suitable compensation is arranged.

When a wash bulkhead is fitted, the length or breadth of a tank may, for the purposes of 5015 and 5029, be measured from the wash bulkhead to the oiltight bulkhead.

**5002** Where the ship's side is framed longitudinally the stiffening on the longitudinal bulkheads is to be arranged horizontally. Vertical stiffening may be adopted in association with transverse side framing.

**5003** Transverse bulkheads may be plane or with corrugations arranged horizontally or vertically.

**5004** The scantlings of cofferdam bulkheads not forming the boundary of a cargo tank are to be as required by D 20 for oil fuel deep tanks.

Where a pump room acts as a cofferdam, a bulkhead which does not form part of the boundary of a cargo tank or an oil fuel bunker may be of watertight bulkhead scantlings in accordance with D 16 except that, in a riveted bulkhead, the riveting is to be as required for an oiltight bulkhead.

**5005** Beyond the ends of the oil tanks the longitudinal bulkheads are to scarph into the adjoining structure.

### PLANE BULKHEADS

#### Plating

**5006** The thickness of the plating is not to be less than

$$t = \left(0{,}31+\frac{h}{61}\right)\frac{s}{30} \text{ mm.},$$

except that the thickness of the top and bottom strakes of longitudinal bulkheads is in no case to be less than:—

$$\text{Top strake} \quad t = \left(0{,}22+\frac{L}{610}\right)\frac{s}{30} \text{ mm.},$$

$$\text{Bottom strake} \quad t = \left(0{,}28+\frac{L}{610}\right)\frac{s}{30} \text{ mm.},$$

where $h$ = distance, in metres, from lower edge of plate to highest point of tank, excluding the hatchway,

$s$ = spacing of stiffeners, in mm.,

$L$ = length of ship, in metres.

The breadth of the top and bottom strakes of longitudinal bulkheads is not to be less than 100D mm.

Where the breadth B exceeds 33,55 metres and a centre-line bulkhead is not required by D 4005 the thickness of the plating of the side longitudinal bulkheads between the aftermost extent of the bulkhead and 0,15L aft of amidships and between 0,15L forward of amidships and the forward cofferdam is to be increased by 1 per cent per 0,3 metre excess breadth if the L/D ratio is 14. No increase is required at an L/D of 12,5 and at intermediate values of L/D the increase is to be obtained by interpolation. Special consideration will be given to the extent of the increase when designs incorporate a number of tanks intended to be empty in the loaded condition.

For minimum thickness *see* D 5308.

#### Stiffeners

**5007** The section modulus of horizontal or vertical stiffeners is not to be less than:—

$$\frac{I}{y} = \frac{s\,S^2}{117{,}5}\,(h + 0{,}9) \text{ cm.}^3$$

where $s$ = spacing in mm.,

$S$ = span in metres measured between girders or from girder to "span point",

$h$ = distance in metres from centre of span to highest point of tank, excluding the hatchway.

The section modulus given by this formula is that of the stiffener and associated plating. (*See* D 5301.)

**5008** The modulus of horizontal stiffeners on longitudinal bulkheads is not to be less than 90 per cent of the modulus of the uppermost side longitudinal.

**5009** The modulus of vertical stiffeners on longitudinal or transverse bulkheads may be reduced by 10 per cent where vertical webs are fitted.

**5010** Stiffeners are to be bracketed or otherwise efficiently connected at their ends to provide adequate fixity and, for horizontal stiffeners, continuity of longitudinal strength at the bulkheads.

The end brackets of longitudinal bulkhead vertical stiffeners are to be as required by Table 63F and are to be connected to a suitable longitudinal or are to be well hollowed and tapered.

All stiffeners are to be connected to the supporting webs or girders as required by Table 63E.

The plating is to be efficiently stiffened to support loads transmitted by end connections of longitudinal bulkhead, shell and deck longitudinals and the like.

### Webs and Girders

**5011** The section modulus of vertical webs and horizontal girders is not to be less than that required by the appropriate formula below:—

| Item | Section Modulus cm.$^3$ |
|---|---|
| 1. Vertical Webs (other than in (2) below) | |
| (a) On transverse bulkheads not forming a ring system but including the web on the centre line. | $12{,}65b \times h \times S^2$ |
| (b) On transverse bulkheads forming a ring system* (other than at centre line) as primary supporting members and supporting horizontal stiffeners. | $10b \times h \times S^2$ |
| (c) On longitudinal bulkheads | 90 per cent of side transverse |
| 2. Intercostal Vertical Webs on Transverse Bulkheads not Supporting Stiffeners | $6{,}9b_1 \times h \times S^2$ |
| 3. Horizontal Girders on Longitudinal or Transverse Bulkheads | |
| (a) Single girder | $11{,}9b \times h \times S^2$ |
| (b) Upper of two or more | $14{,}6b \times h \times S^2$ |
| (c) Middle or lower | $11{,}9b \times h \times S^2$ |

* i.e., in association with bottom and deck girders of Rule scantlings.

In the above:—

$b$ = width of plating supported, in metres,

$h$ = distance in metres from centre of span to highest point of tank, excluding hatchway,

$S$ = span in metres from "span point" to "span point".

For horizontal girders on longitudinal bulkheads a minimum value of 3 metres is to be used.

For intercostal vertical webs not supporting stiffeners (item 2 in above Table) $b_1$ is to be taken as half the breadth of centre tank (or the breadth of wing tank) in metres divided by the number of webs plus one (number of webs to be those in the half breadth of centre tank or breadth of wing tank as appropriate) and $S$ is to be measured between girders or from girder to span point. The maximum value of $6{,}9\ b_1 \times h \times S^2$ is to be used for the full depth of bulkhead.

**5012** Where the distance between transverse bulkheads (whether oiltight or non-oiltight) exceeds $0{,}07L$ or 15,25 metres, whichever is the greater, the section modulus of the vertical web on the longitudinal bulkhead at about the mid-distance is to be the same as that of the increased side transverse. Where the distance between bulkheads is $0{,}085L$ or greater, the vertical web is to be symmetrical on both sides of the longitudinal bulkhead to give a section modulus not less than that of the increased side transverse.

**5013** Where the distance between transverse bulkheads (whether oiltight or non-oiltight) exceeds 16,75 metres the centre line vertical web is to be symmetrical on both sides of the transverse bulkhead.

**5014** Where webs are symmetrical on each side of a plane bulkhead the section modulus derived as above may be reduced by 10 per cent except where the vertical web on the longitudinal bulkhead is required to be symmetrical to comply with 5012.

**5015** Where the breadth of a cargo tank exceeds 13,5 metres the section modulus of the vertical webs and horizontal girders on the longitudinal bulkhead is to be increased at the rate of 2 per cent per 0,3 metre excess above 13,5 metres. (*See also* 5001.)

**5016** Where side transverses are required by D 4503, vertical webs are to be fitted on the longitudinal bulkhead. Where vertical webs are not fitted, the lower horizontal girders are to be supported by suitable buttress brackets from the bottom transverses.

**5017** The depth of a girder or web is not to be less than $2\frac{1}{2}$ times the depth of the slot for the stiffener.

For minimum thicknesses *see* D 5308 and D 5309.

For moduli of webs and girders of various depths, face areas and bulkhead plating *see* D 5305.

**5018** The end attachments of vertical webs and horizontal girders are to have a length of arm at least equal to the depth of web.

## CORRUGATED BULKHEADS

### General

**5019** Where corrugated bulkheads are adopted the corrugations should be arranged in accordance with 5001 and 5003.

**5020** In ships above 183 metres in length the upper and lower strakes of the longitudinal bulkhead are to be plane for a distance of 100D mm. from the deck and bottom and the vertical webs are to be arranged symmetrically on each side of the longitudinal bulkhead. Alternative arrangements with unsymmetrical webs will be specially considered, having in view the spacing of transverses and the type of transverse bulkhead, etc.

### Plating

**5021** The thickness of the plating is not to be less than

$$t = \left(0{,}31 + \frac{h}{61}\right)\frac{s}{30}\text{ mm.}$$

where h = distance, in metres, from lower edge of plate to highest point of tank, excluding hatchway,

s = width of panel, in mm. (flat or inclined surface, i.e., b or c in the figure in 5022, whichever is the greater). A minimum value of 610 is to be used in this formula.

When s exceeds 840 mm. the scantlings will be specially considered.

The thickness of the top and bottom strakes of longitudinal bulkheads is to be not less than required by 5006.

The thickness of plating is also to be such that the requirements of 5022 are satisfied.

Where the breadth B exceeds 33,55 metres and a centreline bulkhead is not required by D 4005 the thickness of the plating of the side longitudinal bulkheads between the aftermost extent of the bulkhead and 0,15L aft of amidships and between 0,15L forward of amidships and the forward cofferdam is to be increased by 1 per cent per 0,3 metre excess breadth if the L/D ratio is 14. No increase is required at an L/D of 12,5 and at intermediate values of L/D the increase is to be obtained by interpolation. Special consideration will be given to the extent of the increase when designs incorporate a number of tanks intended to be empty in the loaded condition.

For minimum thickness *see* D 5308.

**5022** The minimum angle of corrugation is to be 40° and the dimensions of the corrugations are to fulfil the following conditions:—

(1) $\dfrac{t\ d\ (3\ b+c)}{59\ p}$ not to be less than $h\ S^2$

(2) $\dfrac{t\ d^2\ (3\ b+c)}{6030\ p}$ not to be less than $h\ S^3$

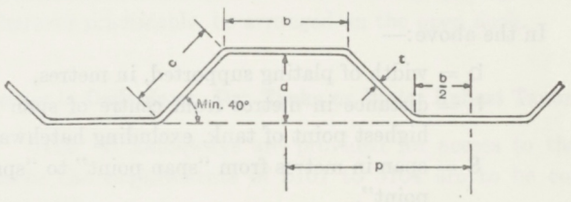
except that when a vertically corrugated transverse bulkhead is supported by two or more horizontal girders 4520p may be substituted for 6030p in (2) for the portion between the girders.

In the above:—

h = distance, in metres, from centre of span to highest point of tank, excluding hatchway,

S = span of corrugation, in metres, measured from girder to girder, transverse to transverse or side, bottom, deck or bulkhead to transverse or girder,

and t, b, c, d and p in mm. are as shown in the sketch below.




In (1) and (2) above the value of b is not to be taken as greater than 50 t. Where unsymmetrical girders or webs are fitted to corrugated bulkheads, the maximum angle of corrugation is to be 60°.

**5023** Corrugations are to be in line, and of the same form, on each side of bulkheads, horizontal girders and vertical webs.

### Webs and Girders

**5024** Horizontal girders and vertical webs are to be arranged to support the corrugations so that the span of the corrugated bulkhead does not exceed 4,88 metres, except that the top span of a vertically corrugated bulkhead may be 5,2 metres. (For vertical webs on longitudinal bulkheads *see also* D 4601.)

**5025** The section modulus of vertical webs and horizontal girders is not to be less than that required by the appropriate formula below:—

| Item | Section Modulus cm.³ |
|---|---|
| 1. VERTICAL WEBS | |
| (a) ON VERTICALLY CORRUGATED BULKHEADS | |
| At centre line | $12{,}65b \times h \times S^2$ |
| Other webs forming a ring system* and not supporting girders | $6{,}9b_1 \times h \times S^2$ |
| (b) ON HORIZONTALLY CORRUGATED BULKHEADS | |
| (i) Tranverse bulkheads: | |
| At centre line | $12{,}65b \times h \times S^2$ |
| Other webs forming a ring system* | $10b \times h \times S^2$ |
| Webs not forming a ring system | $12{,}65b \times h \times S^2$ |
| (ii) Longitudinal bulkheads | 90 per cent of side tranverse |
| 2. HORIZONTAL GIRDERS ON VERTICALLY CORRUGATED TRANSVERSE BULKHEADS | |
| (a) Single girder | $11{,}9b \times h \times S^2$ |
| (b) Upper of two or more | $14{,}6b \times h \times S^2$ |
| (c) Middle or lower | $11{,}9b \times h \times S^2$ |

* i.e., in association with bottom and deck girders of Rule scantlings.

In the above:—

$b$ = width of plating supported, in metres,
$h$ = distance in metres from centre of span to highest point of tank, excluding hatchway,
$S$ = span in metres from "span point" to "span point".

For vertical webs forming a ring system and not supporting girders, $b_1$ is to be taken as half the breadth of the centre tank (or breadth of wing tank) in metres divided by the number of webs plus one and $S$ is to be measured between girders or from girder to span point. The maximum value of $6{,}9\ b_1 \times h \times S^2$ is to be used for the full depth of bulkhead.

**5026** Where the distance between transverse bulkheads (whether oiltight or non-oiltight) exceeds $0{,}07L$ or 15,25 metres, whichever is the greater, the section modulus of the vertical web on the longitudinal bulkhead at about the mid-distance is to be the same as that of the increased side transverses.

Where the web is symmetrical on both sides of the bulkhead, the modulus may be reduced by 10 per cent provided the distance between bulkheads is less than $0{,}085L$.

Where the distance between bulkheads is $0{,}085L$ or greater, the vertical web is to be symmetrical on both sides of the longitudinal bulkhead, to give a section modulus not less than that of the increased side transverse.

**5027** Where the distance between transverse bulkheads (whether oiltight or non-oiltight) exceeds 16,75 metres the centre line vertical web is to be symmetrical on both sides of the transverse bulkhead.

**5028** Where webs or girders are symmetrical on each side of a corrugated bulkhead the section modulus derived as above may be reduced by 10 per cent except where the vertical web on the longitudinal bulkhead is required to be symmetrical to comply with 5026.

**5029** Where the breadth of a cargo tank exceeds 13,5 metres the section modulus of the vertical webs on the longitudinal bulkhead is to be increased at the rate of 2 per cent per 0,3 metre excess above 13,5 metres. (*See also* 5001.)

**5030** For minimum thicknesses *see* D 5308 and D 5309.

For moduli of webs and girders of various depths, face areas and bulkhead plating *see* D 5305.

**5031** The end attachments of vertical webs and horizontal girders are to have a length of arm at least equal to the depth of web.

## NON-OILTIGHT BULKHEADS (PLANE OR CORRUGATED)

### General

**5032** Wash bulkheads and perforated centreline longitudinal bulkheads are to have an area of perforations not less than 10 per cent of the total area of the bulkhead. The perforations are to be so arranged that the bulkheads act as an efficient girder, web or transverse and the lower part of a centreline bulkhead is to be adequately stiffened to act as a docking girder.

Special care is to be taken to ensure that a perforated centreline longitudinal bulkhead provides an efficient connection between the deck and bottom plating.

### Plating

**5033** The thickness of plating may be the compartment minimum (*see* D 5308) except that the top and bottom strakes of a centreline bulkhead are to be as required by 5006 for an oiltight longitudinal bulkhead.

**Stiffeners, Girders and Webs**

**5034** The section modulus of stiffeners and horizontal girders is to be not less than:—

$$\frac{I}{y} = k \times s_1 \times S^2 \times \frac{l}{L} \text{ cm.}^3,$$

where $k = 1215 \times 10^{-4}$ for stiffeners on transverse bulkheads,
$3785 \times 10^{-4}$ for stiffeners on longitudinal bulkheads,
145 for girders on transverse bulkheads,
452 for girders on longitudinal bulkheads,

$s_1$ = spacing of stiffeners, in mm., or width of plating supported by girder, in metres,

$S$ = maximum span of stiffeners between girders, or from girder to "span point", in metres, or span of girder from "span point" to "span point", in metres,

$l$ = length or breadth, in metres, of tank between oiltight bulkheads for transverse or longitudinal bulkheads respectively. Where two or more transverse wash bulkheads are fitted in one tank $l$ is to be measured between the bulkheads adjacent to the wash bulkhead under consideration,

$L$ = length of ship, in metres.

**5035** The section modulus of vertical webs is to be not less than:—

On transverse bulkheads—the modulus required for an oiltight bulkhead multiplied by $\left(0{,}3+2\frac{l}{L}\right)$

where $l$ and $L$ are as defined in 5034.

On longitudinal bulkheads—50 per cent of that required for an oiltight bulkhead.

**5036** The depth of webs and girders is to be at least $2\frac{1}{2}$ times the depth of the slot for the stiffener.

**5037** When determining the width of plating supported and the effective area for calculating the modulus no deduction is to be made on account of perforations.

## Section 51

### HATCHWAYS

**Oiltight Hatchways**

**5101** Oiltight hatchways are to be kept to the minimum size required to provide reasonable access and ventilation to each compartment.

Corners of hatchway openings are to be well rounded and smooth.

**5102** The height of the coaming is not to be less than 255 mm. Coaming plates not exceeding 815 mm. in height are not to be less than 10 mm. in thickness.

**5103** Where the area of the hatchway cover does not exceed 1,12 square metres in a circular hatchway, or 1,49 square metres in a rectangular hatchway, the thickness of the cover is to be 12,5 mm.

If the area exceeds the above but does not exceed 2,32 square metres the thickness of the cover is to be 15 mm. or may be 12,5 mm. if stiffened by 100 mm. flats spaced 610 mm. apart.

**5104** Covers are to be secured by fastenings spaced not more than 457 mm. apart in a circular hatchway or 380 mm. apart in a rectangular hatchway and not more than 230 mm. from the corners.

Hatchway covers of special design with alternative methods of closing will be specially considered.

**Ullage Plugs and Tank Cleaning Openings**

**5105** Ullage plugs or sighting ports are not to be arranged in enclosed spaces. Tank cleaning openings should, wherever practicable, be arranged on the open deck.

**Access to Cofferdams, Dry Tanks or Water Ballast Tanks**

**5106** If hatchways are provided for access to these spaces the requirements of 5101 to 5104 are to be complied with.

**5107** Access may be by a watertight manhole provided the plate cover is not less than 12,5 mm. in thickness and the bolts are not more than 100 mm. apart.

**Hatchways to Spaces other than Oil Tanks, Cofferdams Dry Tanks, or Water Ballast Tanks**

**5108** Hatchways are to be constructed in accordance with the requirements of D 23 except that efficient steel watertight covers are to be fitted to hatchways situated on expansion trunks and on the strength deck, either where exposed or inside open superstructures.

Hatchways situated on the forecastle deck are to have steel covers except where efficient steel watertight covers are fitted to the hatchways inside the forecastle.

## Section 52

### TESTING

#### General

**5201** Each cargo tank and cofferdam is to be separately tested by filling with water to the test head.

When water testing on the building berth or in dry dock may be undesirable, testing may be carried out afloat, provided any riveted shell seams in the bottom and bilge plating are tested with a high pressure hose test on the berth. The testing afloat is to be carried out by separately filling each tank and cofferdam to the test head. With about half the number of tanks full, the bottom and lower side shell in the empty tanks is to be examined and the remainder of the bottom and lower side shell examined when the water is transferred.

When a preservative coating is to be applied to the internal structure of a tank, the water testing may take place after the application of the preservative, provided the structure is carefully examined to ensure that all welding and structural stiffening is completed prior to the application of the coating and any riveted shell seams are tested with a high pressure hose test on the berth before coating. The hose test of the riveted seams may be carried out from the outside to avoid wetting the tank structure.

The cause of any discoloration or disturbance of the coating is to be ascertained and any deficiencies repaired.

**5202** Water ballast and dry tanks should be tested as required for cargo tanks.

**5203** It is recommended that pump rooms be flooded to a suitable depth prior to launch. The bottom and side shell plating is to be carefully examined internally with the vessel at a deep draught. Bulkheads not forming tank boundaries are to be hose tested.

#### Test Head

**5204** The test head for cargo tanks is to be 2,45 metres above the highest point of the tank, excluding hatchways; that for cofferdams is to be to the top of the hatchway.

#### Bunkers and Deep Tanks

**5205** Bunkers and deep tanks are to be tested as required by D 2031 and D 1914 respectively.

## Section 53

### EFFECTIVE SECTION MODULUS, FACE AREAS AND MINIMUM THICKNESSES

#### EFFECTIVE SECTION MODULUS

#### Longitudinals, Frames and Stiffeners

**5301** For longitudinals, side frames and bulkhead stiffeners the section modulus required by the appropriate formula is to be that of the section in association with 610 mm. of plating having the same thickness as the shell, deck or bulkhead plating as appropriate. Where the attached plating is of varying thickness, the mean thickness over the appropriate span is to be used.

The effective section moduli of rolled sections and the area of the section without plating are given in the publication "Geometric Properties of Rolled Sections and Built Girders".

The effective section moduli of flat bars or built sections may be obtained from curves in the above publication.

#### Transverses, Webs, Stringers and Girders

**5302** For transverses, webs, stringers and girders, the section modulus required by the appropriate formula is to be that of the member in association with an effective area of shell, deck or bulkhead plating.

**5303** Except for corrugated bulkheads, the effective area is to be:—

$$A = 10\ k\ b\ t_p \text{ square cm.,}$$

where $k$ = a coefficient obtained from the table below,

$b$ = actual width in metres of load-bearing plating, i.e., one half the sum of spacings of parallel adjacent members of greater or equivalent length (*see* sketches on pages 221 and 222),

$t_p$ = mean thickness of attached shell, deck or bulkhead plating in mm.,

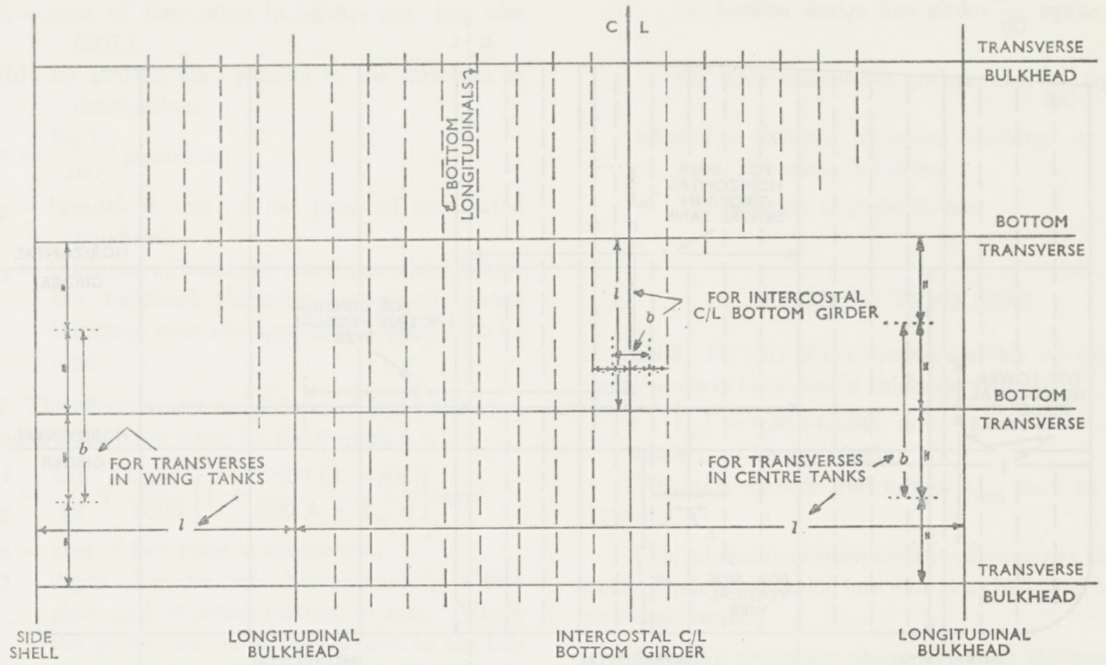
$l$ = overall length of girder, transverse, etc., in metres (*see* sketches on pages 221 and 222).

| $\frac{l}{b}$ | 0,5 | 1,0 | 2,0 | 3,0 | 4,0 | 5,0 | 6,0 |
|---|---|---|---|---|---|---|---|
| k | 0,12 | 0,23 | 0,45 | 0,67 | 0,80 | 0,90 | 1,00 |

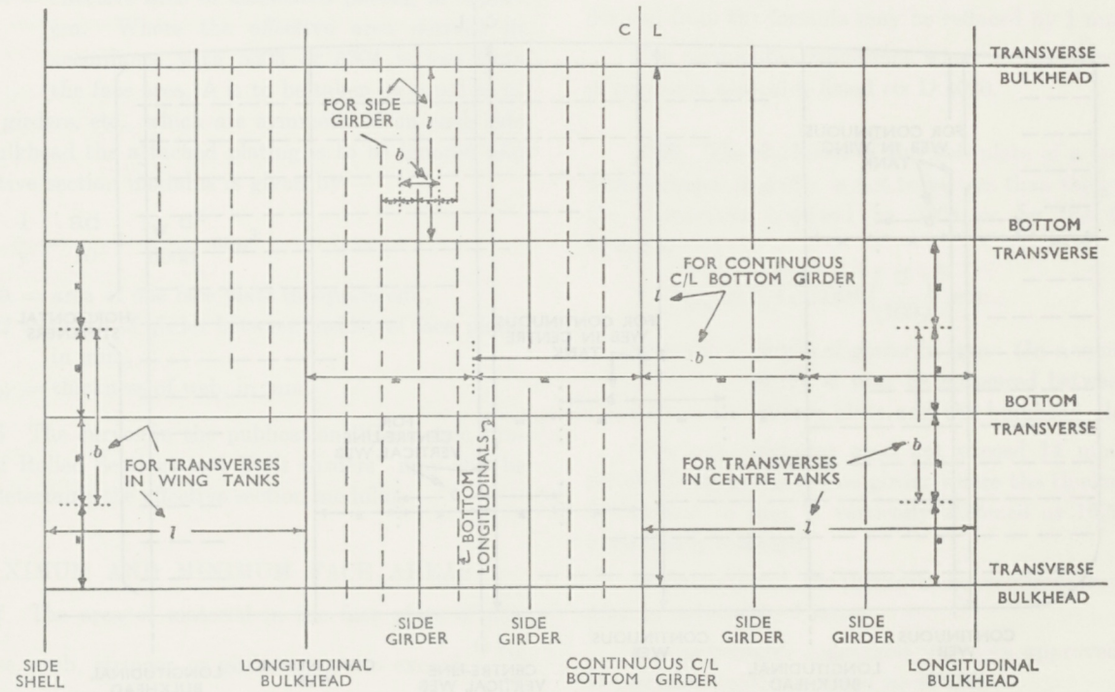
For intermediate values of $\frac{l}{b}$, k is to be obtained by interpolation. Where $\frac{l}{b}$ exceeds 6,0, k is to be taken as 1,0.

## TO ILLUSTRATE PARAGRAPH D 5303

(a) BOTTOM STRUCTURE WITH INTERCOSTAL BOTTOM CENTRE-LINE GIRDER

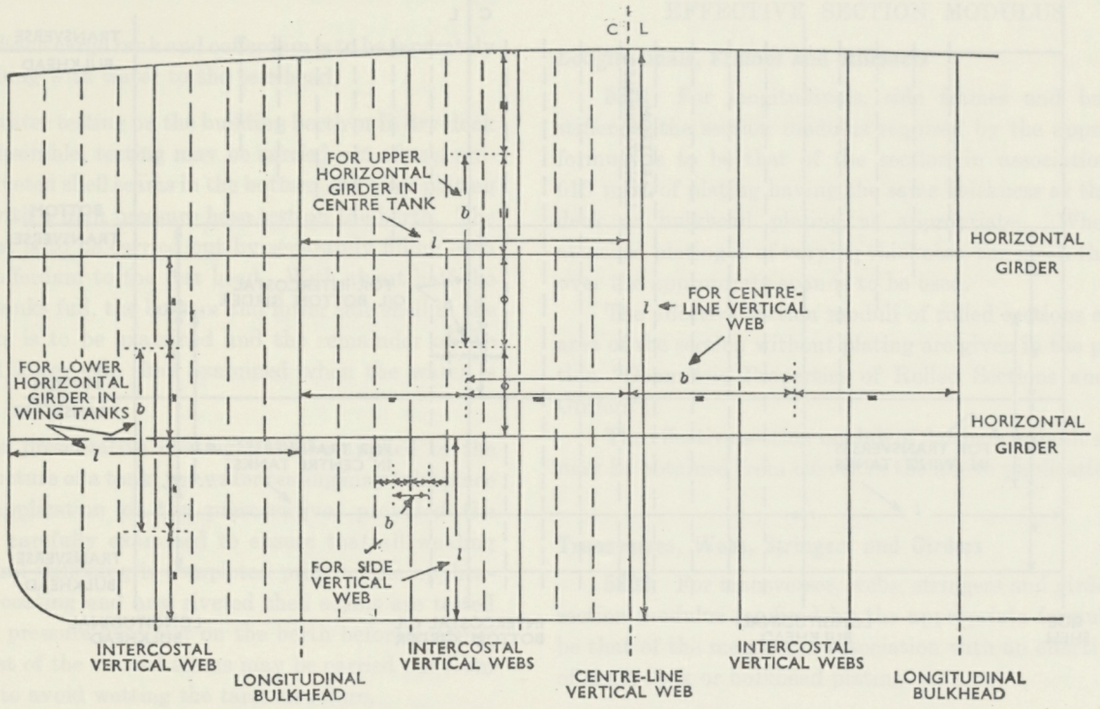



(b) BOTTOM STRUCTURE WITH CONTINUOUS BOTTOM CENTRE-LINE GIRDER

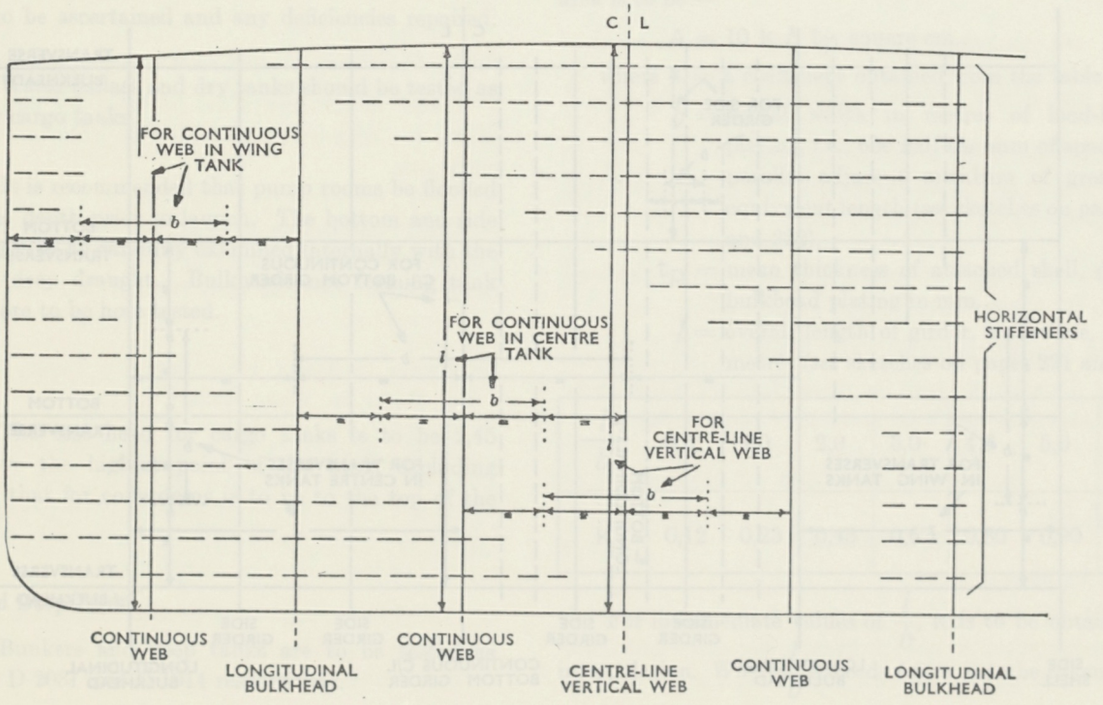


## TO ILLUSTRATE PARAGRAPH D 5303

### (c) TRANSVERSE BULKHEAD WITH VERTICAL STIFFENING




### (d) TRANSVERSE BULKHEAD WITH HORIZONTAL STIFFENING



**5304** For corrugated bulkheads the effective area is to be:—

(a) for girders, etc., at right angles to the direction of corrugations:

$A$ = area of face plate in square cm. (*see also* 5307.)

(b) for girders, etc., parallel to the direction of corrugations:

$$A = \frac{b_c\, t_p}{100} \text{ square cm.,}$$

where $b_c$ = breadth in mm. of flat panel of corrugated bulkhead,

$t_p$ = thickness of bulkhead plating in mm. Where the bulkhead thickness varies, the mean thickness over the appropriate span is to be used.

**5305** The effective section modulus of any transverse, web, stringer or girder is given by the formula:—

$$\frac{I}{y} = \frac{a\,d}{10} + \frac{t_w\, d^2}{6000}\left[1 + \frac{200\,(A - a)}{200\,A + t_w\, d}\right] \text{ cm.}^3$$

where $a$ = area of face plate in square cm.,

$d$ = depth of girder, etc., between inside of face plate and attached plating, in mm. Where the girder, etc., is at right angles to the line of corrugations the minimum depth is to be taken,

$t_w$ = thickness of web in mm.,

$A$ = effective area of associated plating in square cm. Where the effective area derived in accordance with 5303 or 5304 is less than the face area, $A$ is to be taken as equal to $a$.

For girders, etc., which are symmetrical on each side of the bulkhead the attached plating is to be ignored and the effective section modulus is given by:—

$$\frac{I}{y} = \frac{a\,d}{10} + \frac{t_w\, d^2}{6000} \text{ cm.}^3$$

where $a$ = area of one face plate in square cm.,

$d$ = depth of girder between insides of face plates in mm.,

$t_w$ = thickness of web, in mm.

**5306** The curves in the publication "Geometric Properties of Rolled Sections and Built Girders" may also be used to determine the effective section modulus.

## MAXIMUM AND MINIMUM FACE AREAS

**5307** The area of material in the face plate of any transverse, web, stringer or girder is not to exceed $\frac{d\,t_w}{150}$ square cm. where $d$ and $t_w$ are the depth of girder and web thickness as defined in 5305.

The face area is not to be less than:—

(a) bottom centre line girder $\frac{l\,d}{60}$ square cm.,

(b) other transverses, girders, etc., $\frac{l\,d}{240}$ square cm.,

where $l$ = distance between docking or tripping brackets in metres,

$d$ = depth of girder in mm.

## MINIMUM THICKNESS

**5308** No part of the structure within the range of the cargo tanks is to be less in thickness than:—

$$t_{min} = 6{,}85 + 0{,}024L \text{ mm.,}$$

where $L$ = length of ship.

Where $L$ exceeds 198 metres $t_{min}$ may be taken as 11,5 mm.

This minimum also applies to cofferdams at the ends of, or between, cargo tanks, but, except as indicated below, not to pump rooms.

In pump rooms the above minimum thickness applies to shell, decks, longitudinal bulkheads and to the bottom, side, deck and bulkhead longitudinals.

For other items solely within these spaces the minimum derived from the formula may be reduced by 1 mm.

For permissible reductions when an approved system of corrosion control is fitted *see* D 4020.

**5309** The thickness of the web plate of a transverse, web, stringer or girder is not to be less than the greater of the thicknesses required by 5308 or by the following formula:—

$$t_{min} = 8{,}9 + 0{,}008\left(\frac{d}{100}\right)^2 \text{ mm.,}$$

where $d$ = depth of girder in mm. (In a symmetrical girder $d$ may be measured between inside of face plate and the bulkhead plating.)

The web thickness need not exceed 14 mm. except for the bottom centre line girder where the thickness need not exceed 18 mm. if vertically stiffened or 16,5 mm. if horizontally stiffened.

In pump rooms, the thickness derived from this formula may be reduced by 1 mm.

For permissible reductions when an approved system of corrosion control is fitted *see* D 4020.

## Section 54

**STRUCTURAL ARRANGEMENTS AT THE FORE END**

*(see below)*

## Section 55

**STRUCTURAL ARRANGEMENTS AT THE AFTER END**

*(see below)*

## Section 56

**SUPERSTRUCTURES**

*(see below)*

NOTE.—The above three Sections are now being revised and in the meantime Sections 47, 48 and 45 and Tables 73, 74 and 75 in the 1959 Rules are to be used.

## Section 57

**STRUCTURAL DETAILS**

### Transverses, Webs, Stringers and Girders

**5701** All primary supporting members, such as transverses and webs, stringers and girders, are to be so arranged that effective continuity of strength throughout their length is ensured and abrupt changes in depth or section at their connections are avoided; if the edges are flanged, the arrangement at the junction of the member and the bracket is to be of careful design and execution. Primary supporting members are to have adequate end fixity, web stiffening and lateral support.

All longitudinals, stiffeners, etc., are to be attached to the primary supporting member as required by Table 63E.

### Arrangements at Ends of Primary Supporting Members

**5702** When face plates are carried continuously along the edges of end brackets of primary supporting members, their butts are to be kept clear of the toes of the brackets. The full width of the face plate is to be determined as far as the span point.

If not carried along the edge of the bracket the face plates of these members are to extend a reasonable distance beyond the toes of the brackets.

Where a wide face plate abuts on a narrower face plate, the taper is generally not to exceed 1 in 3, elsewhere the taper may be 1 in 2. Where a thick face plate abuts on a thinner face plate, if the difference in thickness exceeds 3 mm., the taper on the thickness is not to exceed 1 in 3.

**5703** End brackets are to be stiffened as follows:—

| Length of free edge | | Bracket stiffening | |
|---|---|---|---|
| Above | Not exceeding | Flange or face plate | Additional flat stiffener |
| mm. | mm. | mm. | mm. |
| — | 1270 | 100 | — |
| 1270 | 1650 | 125 | — |
| 1650 | 2030 | 125 | 100 |
| 2030 | 2540 | 150 | 100 |
| 2540 | — | 200 | 125 |

The bracket stiffener, when required, is to be parallel to the free edge and generally not more than a quarter of the throat depth from it. Large brackets may also require stiffening in line with the girder face plate.

The thickness of the end bracket is not to be less than the thicker of the webs being connected unless additional stiffeners are fitted when the thickness may be reduced by 1 mm., provided the compartment minimum is maintained.

**5704** Brackets are to be well hollowed out or attached to a flat on the bulkhead plating. The flat is to extend to an adjacent stiffener or is to be well tapered off.

End brackets to horizontal girders on the transverse bulkheads are to be carried to the adjacent transverse and vertical web or equivalent arrangements provided.

**5705** The angle between the free edge of the bracket and the face plate of the primary member is not to exceed 45°; if necessary, the edge of the bracket is to be curved at the toe.

**5706** Special attention is to be paid to the tripping brackets of girders or webs on corrugated bulkheads to avoid causing hard spots on the bulkhead. All brackets are to be well hollowed and are to be situated as close to the corner of the corrugation as practicable, or other suitable arrangements made to dissipate the load at the bracket toe.

**5707** Where members abut on both sides of bulkheads or on other members care is to be taken that they are in alignment.

### Web Stiffening

**5708** Stiffeners are to be fitted to web plates at each frame, longitudinal or bulkhead stiffener except that on deck transverses and on side transverses and vertical webs

within 0,25D from the deck at side, the stiffeners need only be fitted at alternate longitudinals. Elsewhere the spacing of stiffeners is generally not to be more than 1050 mm.

Flat bar stiffeners are to have the depth given in the following Table and minimum compartment thickness. Other types of stiffeners are to be of equivalent inertia.

| Depth of Girder | | Stiffeners | |
|---|---|---|---|
| Above | Not exceeding | | |
| mm. | mm. | mm. | |
| — | 610 | 75 | Short and long alternately* |
| 610 | 915 | 100 | Short and long alternately* |
| 915 | 1065 | 125 | Short and long alternately* |
| 1065 | 1220 | 125 | All long |
| 1220 | 1525 | 150 | All long |
| 1525 | 1835 | 180 | All long |
| 1835 | 2135 | 200 | All long |

* All long in way of end brackets.

Where the depth of the web exceeds 2135 mm. the stiffening arrangements will be specially considered, taking into account the number of attached girders, etc., and any stiffeners arranged parallel to the face plate of the girder.

Long stiffeners are to extend to the face edge of the web. In way of end brackets, or where required by 5713, the stiffeners are to be attached to the face plate or equivalent arrangements provided.

Short stiffeners are to extend to half the depth of the web but at least beyond the lightening holes or 150 mm. beyond the notches.

The requirements of Table 63E as regards area of weld are also to be complied with.

**5709** Where bulkheads are horizontally corrugated and the vertical webs are arranged on one side of the bulkhead only, vertical stiffening of the web is to be provided when the depth of the web exceeds 1065 mm. The stiffener should be a 150×90 mm. toe welded angle of minimum compartment thickness or equivalent area.

**5710** Vertical webs on plane transverse bulkheads are to be stiffened in accordance with 5709 when the depth of web exceeds 1900 mm. Similar stiffening may be required on other vertical webs when the depth is excessive.

**5711** Stiffeners of the size given in 5708 are generally to be fitted to the deck centre line girder and bottom and deck side girders not more than 1050 mm. apart. All stiffeners are to extend to the face plate. In deep centre line girders horizontal stiffening is to be arranged.

### Lateral Stability

**5712** Tripping brackets are to be fitted at suitable intervals. In general, they should be fitted near the toes of end brackets and in way of cross ties, while arrangements at the intersections of longitudinal and transverse webs, vertical and horizontal webs should be adequate to prevent tripping. Where the span is long, additional brackets are to be fitted as necessary.

**5713** Where the unsupported width of face plate exceeds 150 mm. the tripping bracket is to be connected to the face plate. Where, with symmetrically placed face plates, the width of face plate exceeds 400 mm. a small bracket connected to the face plate is to be fitted opposite, and in line with, the tripping bracket. Wide face plates may require to be supported between tripping brackets.

### Notches

**5714** All notches are to have well rounded corners and smooth edges and are not to be larger than necessary. When notches occur at points where stress concentration may develop, such as adjacent to the toes of brackets, a welded collar or equivalent reinforcement is to be fitted. Collars are also to be fitted in way of cross ties.

### Lightening, Access, Drain and Air Holes and Holes for Heating Coils, etc.

**5715** The diameter of lightening holes is not to exceed 20 per cent of the depth of the web; the edges of the holes should be placed at not less than 40 per cent of the depth of the web from the face and equidistant from the corners of notches for frames or stiffeners. Lightening holes are not to be cut in horizontal girders on the ship's side and longitudinal bulkheads, in symmetrical webs nor in side transverses and vertical webs in way of cross ties and their end connections. Access holes or foot holes may be cut in deep bottom transverses and centre girders with suitable compensation if necessary. All holes are to have smooth edges and are to be kept well clear of notches and the toes of brackets.

**5716** Small drain or air holes may be cut in deep framing members and in longitudinals and stiffeners. These holes should be kept clear of the toes of end brackets and are to be well rounded with smooth edges. (*See also* D 4107 and Table 62 Note 4.)

**5717** Where holes are cut in the bottom transverses for heating coils the lower edge of the hole is to be not less than 100 mm. from the inside of the shell plating.

**5718** The edges of all holes in transverses are to be at least 180 mm. from the edges of notches for longitudinals.

### Welded Connections

**5719** The requirements for welded connections and details of scalloped construction are given in Table 63. All scallops are to have well rounded corners and smooth edges. (For general particulars *see* Table 63A.) Scallops are not to be cut in way of end brackets, and scallops in the stiffening members are to be at least 230 mm. clear of the toe of the bracket. Scallops in longitudinals, side frames and stiffeners are also to be omitted for at least 230 mm. on each side of intersection with a primary supporting member. Scallops are not to be cut in bottom transverses or in horizontal girders on ship's side or longitudinal bulkheads, and in ships over 122 metres in length, scallops are not to be cut in the lower half of side transverses or vertical webs on longitudinal and transverse bulkheads.

### Riveted Connections

**5720** In riveted construction arrangements are to be generally equivalent to the requirements of this Section and the riveting is to be as required by Table 63.

*21st May, 1964*

# WELDING AND RIVETING

## A

## TYPES OF WELDING

### SIZE OF FILLET WELDS

| PLATING THICKNESS | BASIC THROAT THICKNESS |
|---|---|
| mm. | mm. |
| 6,0 | 4,0 |
| 7,5 | 4,5 |
| 9,0 | 5,0 |
| 10,5 | 5,5 |
| 12,0 | 6,0 |
| 14,0 | 6,5 |
| 16,0 | 7,0 |
| 18,0 | 8,0 |
| 20,5 | 9,0 |
| 23,0 | 10,0 |
| 25,5 | 11,0 |

**NOTES.—TABLE 63A**

1. **Basic throat thickness** is to be governed by the thickness of the abutting plate or web. Where the difference between the thickness of the parts to be joined is considerable the size of fillet will be specially considered.

2. **Basic throat thickness** for intermediate thickness to be obtained by direct interpolation.

3. **Throat thickness for double continuous fillets** is the product of Basic Throat Thickness and the Weld Factor required by Tables 63G and 63H.

4. **Throat thickness for intermittent fillets** is to be given by the formula

   Throat thickness = Basic Throat Thickness × Weld Factor × $\frac{d}{s}$ where s and d are as defined in the sketches below. The length s should not be less than 75 mm. and s and d are to be such that the required throat thickness does not exceed the Basic Throat Thickness.

5. **Minimum throat thickness** of fillet weld to be 0,80 of the Basic Throat Thickness except where a reduction is allowed by Notes to Tables 63E, 63G and 63H. In no case is the throat thickness to be less than 3,5 mm.

6. **Leg length** of welds is not to be less than 140 per cent of the required throat thickness.

STAGGERED INTERMITTENT

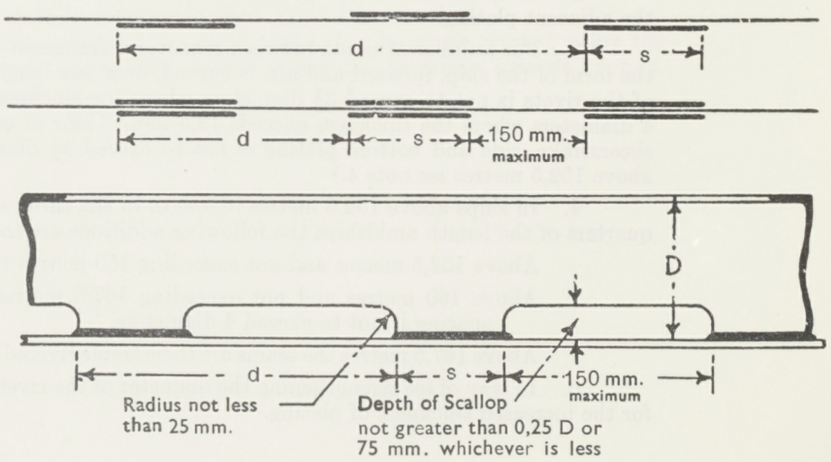
To be doubled at ends. *See* D 3117

CHAIN INTERMITTENT

SCALLOPED FRAMES, LONGITUDINALS, STIFFENERS, etc., WITH DOUBLE FILLET WELDS

Welding to be carried round the ends of all lugs

*See also* D 5719



# TABLE 63 B

## WELDING AND RIVETING

## B

### RIVETING OF SEAMS OF SHELL PLATING

| ITEM | THICKNESS | | SEAMS | | | |
|---|---|---|---|---|---|---|
| | Above | Not exceeding | Diameter of rivets | Type | Breadth | Spacing of rivets centre to centre |
| | mm. | mm. | mm. | | mm. | mm. |
| Sheerstrake between 0,25L aft of amidships and 0,2L forward of amidships | *See* note 2 | | | | | |
| Bottom plating from keel to upper turn of bilge between 0,25L aft of amidships and 0,2L forward of amidships | | 12,5 | 19 | Double | 115 | 65 |
| | 12,5 | 18,5 | 22 | Double | 135 | 90 |
| | 18,5 | 24 | 25 | Double | 150 | 100 |
| | 24 | 32 | 28 | Double | 170 | 115 |
| | 32 | 38 | 28 | Treble | 240 | 115 |
| Sheerstrake at ends<br>Side shell plating from upper turn of bilge to sheerstrake<br>Bottom plating from keel to upper turn of bilge at ends | | 12,5 | 19 | Double | 115 | 65 |
| | 12,5 | 18,5 | 22 | Double | 135 | 90 |
| | 18,5 | 24 | 25 | Double | 150 | 100 |
| | 24 | 29 | 28 | Double | 170 | 115 |
| Keel | *See* note 2 | | | | | |

*See* notes 4 & 5

**NOTES.—TABLE 63 B**

1. Double riveted seams in association with 31 mm. rivets may be fitted as an alternative to treble riveted seams and 28 mm. rivets.

2. In seams of keel and sheerstrake the diameter of rivets and type of seam are to be regulated by the adjacent plating.

3. For number of rivets between transverse frames in seams of side plating *see* Table 63D. Where the form of the ship, forward and aft, is curved, or where longitudinal side framing is adopted, the spacing of the rivets is not to exceed $3\frac{1}{2}$ diameters where the thickness of plating does not exceed 12,5 mm. and 4 diameters where the thickness exceeds 12,5 mm. Clear of cargo tanks the spacing of rivets in seams of sheerstrake, side and bottom plating is not to exceed $4\frac{1}{2}$ diameters. (For special requirements for ships above 152,5 metres *see* note 4.)

4. In ships above 152,5 metres in length in the three seams nearest the neutral axis and for three-quarters of the length amidships the following additions are to be made:—

Above 152,5 metres and not exceeding 160 metres the spacing is not to exceed $3\frac{1}{2}$ diameters.

Above 160 metres and not exceeding 167,5 metres the seams are to be treble riveted and the spacing is not to exceed 4 diameters.

Above 167,5 metres the seams are to be treble riveted and the spacing is not to exceed $3\frac{1}{2}$ diameters.

5. In way of ice strengthening the diameter of the rivets used may be 3 mm. less than that required for the increased thickness of plating.

# WELDING AND RIVETING

## C

## RIVETING OF SEAMS OF DECK PLATING

| ITEM | THICKNESS | | SEAMS | | | |
|---|---|---|---|---|---|---|
| | Above | Not exceeding | Diameter of rivets | Type | Breadth | Spacing of rivets centre to centre |
| | mm. | mm. | mm. | | mm. | mm. |
| Strength deck stringer plate | *See* note 2 | | | | | |
| Strength deck plating | | 12,5 | 19 | Double | 115 | *See* note 4 |
| | 12.5 | 18,5 | 22 | Double | 135 | 90 |
| | 18,5 | 24 | 25 | Double | 150 | 100 |
| | 24 | 32 | 28 | Double | 170 | 115 |
| | 32 | 38 | 28 | Treble | 240 | 115 |
| Sheerstrake stringer connection | *See* note 3 | | | | | |

### NOTES.—TABLE 63 C

1. Double riveted seams in association with 31 mm. rivets may be fitted as an alternative to treble riveted seams and 28 mm. rivets.

2. In seams of stringer plates the diameter of rivets and number of rows are to be regulated by the thickness of adjacent deck plating.

3. The sheerstrake stringer connection is to be double riveted over the cargo tanks and for $\frac{1}{3}$ B into the poop. Where the length L exceeds 228,5 metres, or where the seams of the deck plating are to be treble riveted, the sheerstrake stringer connection is also to be treble riveted. The diameter of the rivets is to be governed by the thickness of the stringer bar and the rivets are to be spaced 5 diameters apart in each row. At the end of the ship the riveting is to be in accordance with Table 19.

4. The seams of strength deck plating at ends clear of oil tanks may be single riveted where the thickness of plating does not exceed 18 mm. and double riveted where the thickness exceeds 18 mm. The rivets are to be spaced $4\frac{1}{2}$ diameters apart.

# TABLE 63 D

## WELDING AND RIVETING

## D

### NUMBER OF RIVETS IN SEAMS OF SIDE SHELL PLATING BETWEEN TRANSVERSE FRAMES EXCLUDING RIVETS IN FRAMES

| FRAME SPACING | THICKNESS OF SIDE SHELL IN MILLIMETRES | | |
|---|---|---|---|
| | Not exceeding 12,5 | Above 12,5 and not exceeding 18,5 | Above 18,5 and not exceeding 24 |
| | DIAMETER OF RIVET IN MILLIMETRES | | |
| | 19 | 22 | 25 |
| | NUMBER OF RIVETS IN EACH ROW | | |
| Millimetres | | | |
| 610 | 8 | 6 | |
| 620 | 8 | 6 | |
| 630 | 9 | 6 | |
| 640 | 9 | 7 | |
| 650 | 9 | 7 | |
| 660 | 9 | 7 | 6 |
| 670 | 9 | 7 | 6 |
| 680 | 9 | 7 | 6 |
| 690 | 9 | 7 | 6 |
| 700 | 10 | 7 | 6 |
| 710 | 10 | 7 | 6 |
| 720 | 10 | 7 | 6 |
| 730 | 10 | 8 | 7 |
| 740 | 10 | 8 | 7 |
| 750 | 10 | 8 | 7 |
| 760 | 11 | 8 | 7 |
| 770 | 11 | 8 | 7 |
| 780 | 11 | 8 | 7 |
| 790 | 11 | 8 | 7 |
| 800 | 11 | 8 | 7 |
| 810 | 11 | 8 | 7 |
| 820 | | 9 | 7 |
| 830 | | 9 | 8 |
| 840 | | 9 | 8 |
| 850 | | 9 | 8 |
| 860 | | 9 | 8 |
| 870 | | 9 | 8 |
| 880 | | 9 | 8 |
| 890 | | 9 | 8 |
| 900 | | 9 | 8 |
| 910 | | 10 | 8 |
| 920 | | 10 | 8 |

**NOTES.—TABLE 63 D**

1. For spacing of rivets clear of cargo tanks and where the form of the ship is curved *see* Table 63 B, Note 3.
2. For special requirements in ships above 152,5 metres in length *see* Table 63 B, Note 4.

# WELDING AND RIVETING

## E

## CONNECTIONS OF LONGITUDINALS, FRAMES AND STIFFENERS TO PRIMARY SUPPORTING MEMBERS

1. The area of welds connecting longitudinals, frames and stiffeners to primary supporting members is not less than that given by the formula

$$A = 0{,}88\sqrt{\frac{I}{y}} \text{ or 13 square cm., whichever is greater,}$$

where $A$ = Area of weld in square cm. as defined in 2 below,

$\frac{I}{y}$ = Section modulus of longitudinal, frame or stiffener in $cm.^3$

2. Area of weld is the product of the throat thickness and the total length of weld and includes both weld of web connection and weld of connection to stiffening bar. The throat thickness is not to be less than 80 per cent of that of the weld required by Table 63A.

3. The area of weld required by 1 above is for bottom and side transverses; for deck transverses the area of weld is not to be less than half the value required by the formula.

4. Outside the tank space the area of weld may be 80 per cent of the value required by the formula and associated notes. The throat thickness of weld is not to be less than 67 per cent of that of the weld required by Table 63A with a minimum of 3,5 mm.

# WELDING AND RIVETING

## F

## BRACKETS AT HEAD OF SIDE FRAMES AND AT ENDS OF VERTICAL STIFFENERS TO LONGITUDINAL AND TRANSVERSE BULKHEADS

1. The dimensions of brackets and their connections are not to be less than those given by the following formulæ:—

Length of Arm ($l$) $= 28{,}3\sqrt{\frac{I}{y}} + 50$ mm.

Thickness $= 0{,}184\sqrt{\frac{I}{y}} + 6{,}5$ mm. or 9 mm., whichever is greater but need not exceed 12,5 mm.

Flange Width (see 4 below) $= 3{,}14\sqrt{\frac{I}{y}} + 12{,}5$ mm. or 100 mm. whichever is less.

Weld area (see 2 below) $= 0{,}042\ l$ square centimetres if $l \leq 610$ mm.

,, $= 0{,}064\ l - 13$ square centimetres if $l > 610$ mm.

Dia. of Rivets $=$ 19 mm. if $\frac{I}{y} \leq 245$ cm.$^3$

,, $=$ 22 mm. if $\frac{I}{y} > 245$ cm.$^3$

Number of Rivets $= 0{,}346\sqrt{\frac{I}{y}} + 0{,}5$ for 19 mm. rivets.

,, $= 0{,}346\sqrt{\frac{I}{y}} - 0{,}7$ for 22 mm. rivets.

Where $\frac{I}{y}$ = Section modulus of frame or stiffener in cm.$^3$

2. Area of weld is the product of the throat thickness and the total length of weld, but the throat thickness is not to be less than 80 per cent of that of the weld required by Table 63A.

3. Length of bracket arm is to be measured from the plating.

4. Flanges need not be fitted where the length of bracket arm is less than 460 mm.

5. For minimum thickness *see* D 5308.

# WELDING AND RIVETING

## G

## CONNECTION OF PRIMARY SUPPORTING MEMBERS TO FACE MATERIAL, SHELL, DECK AND BULKHEAD

| FACE AREA | | POSITION | WELDED | | RIVETED | | |
|---|---|---|---|---|---|---|---|
| | | | TO FACE MATERIAL | TO SHELL, DECK OR BULKHEAD | TO FACE MATERIAL | TO SHELL, DECK OR BULKHEAD | |
| | | | WELD FACTOR | WELD FACTOR | MAXIMUM SPACING OF RIVETS, CENTRE TO CENTRE IN DIAMETERS | NUMBER OF ROWS | MAXIMUM SPACING OF RIVETS, CENTRE TO CENTRE IN DIAMETERS |
| Square Centimetres Above | Not exceeding | | | | | | |
| | **30,0** | For a distance each end equal to 0,2 × length | 0,33 | 0,67 | 7 | Double | 5 |
| | | Remainder ... ... ... ... ... | 0,21 | 0,33 | 7 | Single | 5 |
| **30,0** | **65,0** | For a distance each end equal to 0,2 × length | 0,50 | 0,80 | 4 | Double | 5 |
| | | Remainder ... ... ... ... ... | 0,25 | 0,60 | 6 | Double | 5 |
| **65,0** | **95,0** | For a distance each end equal to 0,2 × length | 0,80 | 0,80 | 5 | Double with single riveted backbar | $4\frac{1}{2}$ |
| | | Remainder ... ... ... ... ... | 0,80* | 0,80 | 6 | Double | $4\frac{1}{2}$ |
| **95,0** | **130,0** | For a distance each end equal to 0,2 × length | 0,80 | 1,00 | 4 | Double with single riveted backbar | 4 |
| | | Remainder ... ... ... ... ... | 0,80* | 0,80 | 5 | Double | 4 |
| **130,0** | **260,0** | For a distance each end equal to 0,2 × length | 1,00 | 1,00 | | | |
| | | Remainder ... ... ... ... ... | 0,80 | 1,00 | | | |

* May be 0,67 clear of oil cargo tanks

### NOTES.—TABLE 63 G

1. Length for use in the above Table is the unsupported length of the member including end connections.

2. The extent of the increased connection at each end equal to 0,2 × length given in the above Table is measured from the end of the member including the end bracket, but this length is to be extended as necessary beyond the toe of the bracket, and beyond the heel of the bracket to cover a contiguous member.

3. On vertical webs the increased welding or riveting may be omitted at the top, but at the bottom it is to extend for a distance equal to 0,3 × length.

4. In ships over 122 metres long the weld factor of the connection of bottom transverses to the shell is not to be less than 0,80 and that of the side transverses to shell, and the vertical webs to longitudinal and transverse bulkheads is not to be less than 0,80 in the lower half; in riveted ships these connections are not to be less than double riveted angles.

5. Centre line deck and bottom girders are to be welded or riveted as given in the above Table.

6. For particulars of scalloped construction *see* D 5719 and notes under Table 63A.

TABLE 63 H
(SEE CONTINUATION)

# WELDING AND RIVETING

## H

## WELDING OR RIVETING OF VARIOUS STRUCTURAL CONNECTIONS

| ITEM | | | WELDED: WELD FACTOR | RIVETED: MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS |
|---|---|---|---|---|
| **FRAMES & LONGITUDINALS** | | | | |
| Side frames to shell | | in cargo tanks, spacing not over 760 mm. ... | 0,25 | 6 |
| | | in cargo tanks, spacing over 760 mm. ... | 0,27 | $5\frac{1}{2}$ |
| | | in deep, oil fuel and peak tanks ... ... | 0,27 | $5\frac{1}{2}$ |
| | | in fore hold ... ... ... ... ... | 0,27 | $5\frac{1}{2}$ |
| | | in machinery space, spacing not over 740 mm. ... ... ... ... ... | 0,21 | 7 |
| | | in machinery space, spacing over 740 mm. and up to 810 mm. ... ... ... | 0,23 | $6\frac{1}{2}$ |
| | | in machinery space, spacing over 810 mm. and up to 860 mm. ... ... ... | 0,25 | 6 |
| | | in machinery space, spacing over 860 mm. ... | 0,27 | $5\frac{1}{2}$ |
| Tween deck frames and longitudinals to shell ... ... ... | | | 0,21 | 7 |
| Web frames ... ... ... ... ... ... ... ... | | | *See* Table 63 G | |
| Bottom longitudinals to shell (except as below) | Where the length L does not exceed 122 metres | For a distance either side of the bulkhead equal to 0,25 × spacing of transverses ... ... ... | 0,80 | 4 |
| | | remainder (except in the forward 0,25 L)... ... ... ... | 0,25 | 6 |
| | Where the length L does exceed 122 metres | For a distance either side of the bulkhead equal to 0,30 × spacing of transverses ... ... ... | 0,80 | $3\frac{1}{2}$ with back angle |
| | | remainder (except in the forward 0,25 L)... ... ... ... | 0,25 | 6 |
| | In the forward 0,25 L (except at the ends of span, where as above) ... ... ... ... | | 0,50 | $4\frac{1}{2}$ with back angle |
| Bottom longitudinals of flatbar type to shell ... ... ... | | | Continuous weld—throat thickness 25 per cent of thickness of the thinner member being connected but need not exceed 5,5 millimetres (manual) or 4,5 millimetres (automatic). | |
| Side longitudinals to shell (*cont. next page*) | Not over 4,6 metres below upper deck at side amidships ... ... ... ... ... | | 0,25 | 6 |
| | over 4,6 metres and not over 7,6 metres below upper deck at side amidships | For a distance either side of bulkhead equal to 0,25 × spacing of transverses ... | 0,80* | $4\frac{1}{2}$ |
| | | remainder ... ... ... | 0,25 | 6 |

* May be 0,67 clear of oil cargo tanks

*For notes see page 236*

# WELDING AND RIVETING

## H (*continued*)

### WELDING OR RIVETING OF VARIOUS STRUCTURAL CONNECTIONS

| ITEM | WELDED | RIVETED |
|---|---|---|
| | WELD FACTOR | MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS |
| Side longitudinals to shell (*continued*) — Over 7,6 metres below upper deck at side amidships — For a distance either side of bulkhead equal to 0,25 × spacing of transverses ... ... ... | 0,80 | $3\frac{1}{2}$ |
| Side longitudinals to shell (*continued*) — Over 7,6 metres below upper deck at side amidships — remainder ... ... ... | 0,25 | 6 |
| Deck longitudinals to deck plating, except as below ... ... | 0,25 | 6 |
| Deck longitudinals of flatbar type to deck plating... ... ... | Continuous weld—throat thickness 25 per cent of thickness of the thinner member being connected but need not exceed 5,5 millimetres (manual) or 4,5 millimetres (automatic). | |
| Longitudinals to stiffening bars on primary supporting members ... | *See* Table 63 E | |
| Intercostal bottom side girders to shell ... ... ... ... | As for bottom longitudinals | |
| Intercostal deck side girders to deck plating ... ... ... | As for deck longitudinals | |
| Face bar of intercostal bottom and deck side girders to respective web plates ... ... ... ... ... ... ... ... | 0,30 | 7 |
| Bottom frames to shell and floors forward ... ... ... | 0,50 | $5\frac{1}{2}$—double riveted |
| Floors to centre girder or centre line bulkhead forward ... ... | 1,00 | 4—double riveted |
| Floors and cross ties in fore peak ... ... ... ... ... | 0,25 | 6 |
| Floors and cross ties in after peak ... ... ... ... ... | 0,30 | 5 |
| **PRIMARY SUPPORTING MEMBERS** | | |
| Bottom transverses to shell ... ... ... ... ... | *See* Table 63 G | |
| Side transverses to shell ... ... ... ... ... | | |
| Deck transverses to deck plating ... ... ... ... | | |
| Web frames to shell ... ... ... ... ... ... | | |
| Vertical webs on longitudinal and transverse bulkheads ... | | |
| Stringers to shell ... ... ... ... ... ... | | |
| Horizontal girders to O.T. bulkheads ... ... ... | | |
| Bottom transverses to longitudinal bulkheads and centre line girders | 1,00 | |
| Deck transverses to longitudinal bulkheads and centre line girders | 0,80 | 5—double riveted |
| **BRACKETS** | | |
| End brackets to all primary supporting members ... ... | 1,00 | |
| Brackets at head of side frames ... ... ... ... ... | *See* Table 63 F | |
| Side frames to bilge brackets ... ... ... ... ... | To depend on arrangements adopted. | |
| End connections of longitudinals ... ... ... ... ... | Generally 1,00 but to depend on design. | |
| Brackets at ends of stiffeners on transverse bulkheads ... ... | To depend on end connections of longitudinals | |
| Tripping brackets ... ... ... ... ... ... ... | 0,25 | 6 |
| Docking brackets ... ... ... ... ... ... ... | 0,30 | 5 |
| Stiffening of primary supporting members *See also* Table 63 E ... | 0,21 | 7 |

*For notes see page 236*

TABLE 63 H
(CONCLUDED)

# WELDING AND RIVETING

## H (*concluded*)

### WELDING OR RIVETING OF VARIOUS STRUCTURAL CONNECTIONS

| ITEM | | | | WELDED | RIVETED |
|---|---|---|---|---|---|
| | | | | WELD FACTOR | MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS |
| **O.T. TRANSVERSE & LONGITUDINAL BULKHEADS** | | | | | |
| Vertical stiffeners | spacing not exceeding 760 mm. ... ... ... | | | 0,25 | 6 |
| | spacing exceeding 760 mm. ... ... ... | | | 0,27 | $5\frac{1}{2}$ |
| Horizontal stiffeners | Not over 4,6 metres below highest point of tank ... | | | 0,25 | 6 |
| | on longitudinal bulkheads | over 4,6 metres and not over 7,6 metres | For a distance either side of bulkhead equal to 0,25 × spacing of transverses | 0,80 | $4\frac{1}{2}$ |
| | | | remainder ... ... | 0,25 | 6 |
| | | over 7,6 metres | For a distance either side of bulkhead equal to 0,25 × spacing of transverses | 0,80 | $3\frac{1}{2}$ |
| | | | remainder ... ... | 0,25 | 6 |
| | on transverse bulkheads | Not over 5,5 metres below highest point of tank ... | | 0,25 | 6 |
| | | over 5,5 metres ... ... ... | | 0,30 | 5 |
| Boundaries | of longitudinal bulkheads to bottom or deck ... | | | 1,00 (continuous) *See* note 2. | 5—double riveted |
| | of transverse bulkheads | to shell at bottom or bilge ... | | 1,00 (continuous) | 5—double riveted |
| | | to shell at sides or to deck ... | | 0,80 (continuous) | 5—double riveted |
| | | to longitudinal bulkheads ... | | 0,80 (continuous) | 5—double riveted |
| Vertical webs ... ... ... ... ... ...<br>Horizontal girders ... ... ... ... ... ... | | | | *See* Table 63 G | |

**NOTES.—TABLE 63 H**

1. Within the cargo tanks double continuous fillets having a throat thickness of less than 0,80 of the Basic Throat Thickness (Table 63A) are to be restricted to longitudinal framing and to bulkhead stiffening, and, apart from longitudinals of the flatbar type, are to have a minimum throat thickness of 3,5 mm. or 0,67 of the Basic Throat Thickness, whichever is greater.

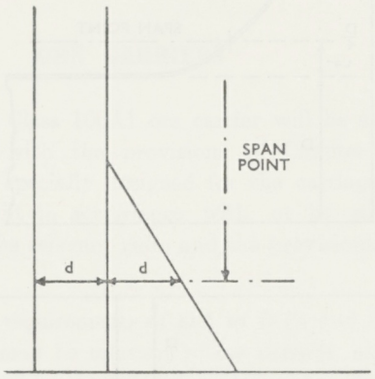
2. Where the top and bottom strakes of the longitudinal bulkhead are increased in thickness above the requirements of D 5006 the welding to deck or bottom shell is not to be less than that based on the thickness required by D 5006 or a throat thickness 25 per cent of the actual plating thickness, whichever is the greater.

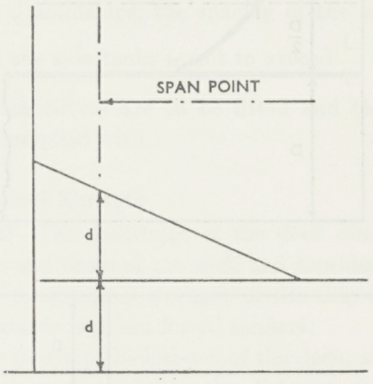
3. The breadths of flanges of connecting angles are generally to be not less than four times the rivet diameter for rivets up to 22 mm. in diameter and three-and-a-half times for rivets 25 mm. and above in diameter.

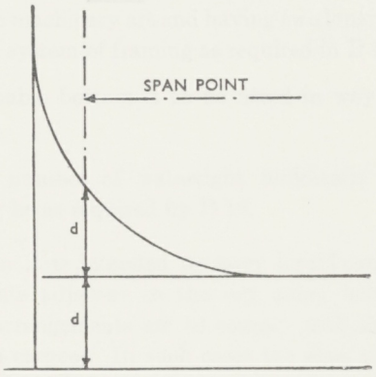
4. The distance from the centre of the rivet hole to the edge of the angle is to be not less than one-and-a-half rivet diameters.

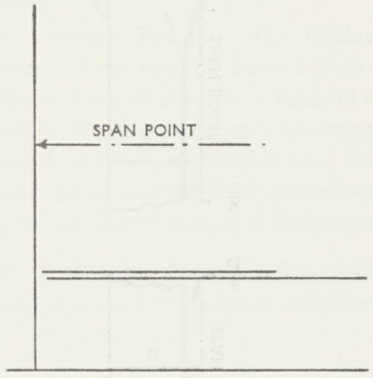
# SPAN POINT

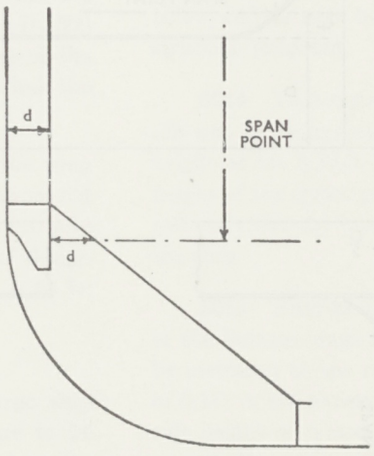
## FOR LONGITUDINALS, FRAMES AND STIFFENERS



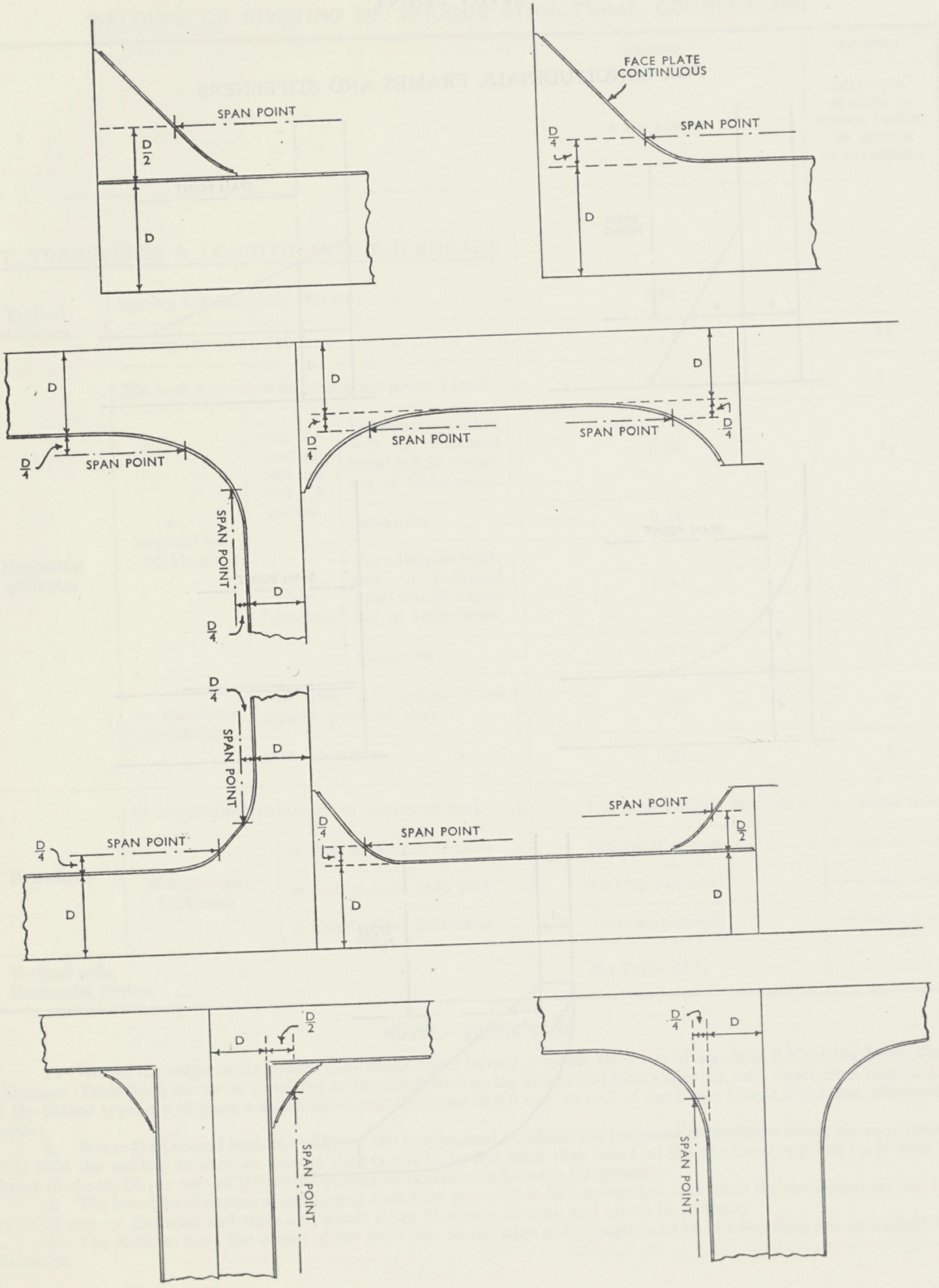



# SPAN POINT

## FOR PRIMARY SUPPORTING MEMBERS



# SHIPS SPECIALLY DESIGNED FOR CARRYING ORE

## Section 60

### ORE CARRIERS

**General**

**6001** The Class 100A1 ore carrier will be assigned, in accordance with the provisions of Chapter B, to sea-going ships specially designed for the carriage of ore cargoes and built in accordance with, or by standards equivalent to, the relevant rules and the provisions of this Section.

**6002** The requirements of D 1 to D 34 and D 40 to D 57 apply as may be relevant to ore carriers, except as otherwise required by the following rules.

**Structural Design**

**6003** The following rules are intended for single deck ore carriers, with machinery aft and having two longitudinal bulkheads and a system of framing as required in D 4003.

**6004** A double bottom is to be fitted in way of the cargo holds.

**6005** The number of watertight bulkheads in the cargo holds may be as required by D 16.

**6006** When it is intended to carry liquid cargoes in the compartments adjacent to the dry cargo holds, the scantlings and arrangements are to comply with the rules relevant to such cargoes. In such cases the class notation may be suitably modified.

**6007** When an approved system of corrosion control is fitted in the wing tanks or tanks under ore holds, the reduction in scantlings given in D 4020, D 5308 and D 5309 can generally be applied except that the thickness of the longitudinal bulkhead may only be reduced by one half the allowance given.

**6008** When low flash point oil is carried in the wing tanks and anodes are fitted, they are to be of approved design and securely attached to the structure, both initially and during service. A plan showing the details of design and attachement and the location of the anodes is to be submitted.

**Draught**

**6009** When a draught in excess of the cargo ship draught is desired, the longitudinal bulkheads are to be not less than 0,2B from the ship's sides measured at the draught d amidships, the spacing of the watertight bulkheads in the side tanks is not to exceed $\frac{L}{24} + 6{,}10$ metres, steel hatch covers are to be fitted and the provisions of D 4013 complied with.

**Longitudinal Strength**

**6010** The scantlings of the deck outside the line of openings and those of the shell and topsides are to be such that the longitudinal strength of the ship is equivalent to the standards required for oil tankers.

The midship thicknesses of the deck, shell and topside plating are to extend over the distances required by D 42 and D 43.

**Shell Plating**

**6011** Bottom Plating The thickness of the keel and bottom plating may be derived from D 7 and Table 14, but the thickness derived from Table 14 is to be increased at the rate of 10 per cent for each increment of 0,1D in the excess height of the inner bottom over the rule height of centre girder given in Table 6. The thickness of the bottom plating need not, however, exceed the requirements of D 43.

**6012** Side Shell Plating The thickness of the side shell plating is to be in accordance with the requirements of D 43.

**Double Bottom Structure**

**6013** The scantlings and arrangements in the double bottom are generally to be governed by D 5 modified as below and as may be necessary to suit the details of construction proposed.

**6014** Transverses Transverses under cargo holds are not to be spaced more than 2,45 metres apart. The height of the double bottom is not to be less than the rule height of the centre girder given in Table 6 increased in the ratio of twice the breadth of the ore hold to the breadth of the ship.

**6015** Bottom Longitudinals The section modulus of the bottom longitudinals as derived from Table 10 is to be increased at the rate of 50 per cent for each increment of 0,1D in the excess height of the double bottom over the rule height of centre girder given in Table 6, but need not exceed the requirements of D 44.

**6016** INNER BOTTOM LONGITUDINALS The section modulus of the inner bottom longitudinals as derived from Table 10 is to be increased in the ratio of breadth of ship to breadth of ore hold, but is to be at least 20 per cent above the requirements of D 5.

Struts should not be fitted to the longitudinals between the floors.

**6017** INNER BOTTOM PLATING The thickness of the inner bottom plating is to be increased by 5 mm. above the requirements of Table 6, or alternatively a double ceiling is to be fitted.

**Side and Deck Longitudinals**

**6018** Side and deck longitudinals are to be in accordance with the requirements of D 44.

*28th February, 1963*

**Transverse Side Framing**

**6019** Transverse side frames are to be in accordance with the requirements of D 45.

**Hatch Covers**

**6020** Steel hatch covers are to be in accordance with D 2326 and the scantlings determined from the formulæ given in Table 43, note 6. When a draught in excess of the cargo ship draught is desired, the section modulus and moment of inertia of the stiffeners and thickness of the plating are to be increased by 15 per cent.

**Equipment**

**6021** The equipment is to be in accordance with D 33 modified, if required, by D 4017.

**6022** Special consideration is to be given to details of construction not specifically mentioned in the above rules.

# APPLICATION OF HIGHER TENSILE STEEL

## Section 65

### GENERAL

**Class Notation**

**6501** The class notation "Higher Tensile Steel" will be assigned, in accordance with the provisions of Chapter B, to ships where higher tensile steel is extensively used in the main hull structure.

**6502** To facilitate ordering of material for repairs, it is recommended that a plan should be placed on board indicating the location and extent of the higher tensile steel, together with details of the specification, including mechanical properties, of the steel.

**Method of Construction**

**6503** The following requirements are applicable to ships where the bottom and deck are framed longitudinally. Proposals with transverse framing will be specially considered.

**Material**

**6504** The higher tensile steel to be used is to comply with the requirements of P 219 to P 227.

**6505** For scantling purposes a factor k shall be derived for the steel as follows:—

$$k = \frac{70,9}{Y + U}$$

where Y = specified minimum upper yield stress or 0,5% proof stress in kg. per mm.$^2$ or 0,7U whichever is the less.

U = specified minimum tensile strength plus one-half of the specified range, in kg. per mm.$^2$.

Special consideration will be given to steels where Y is less than $0,5 \times U$.

## Section 66

### LONGITUDINAL STRENGTH

**Tankers**

**6601** The numeral N as determined in accordance with D 41 is to be multiplied by the factor k or by $0,0625 \frac{L}{D}$ whichever is the greater.

Where higher tensile steel is used for all continuous longitudinal members of the hull the deck and bottom areas are to be determined by D 4107 using the value of N corrected as above.

**6602** Where both higher tensile steel and ordinary mild steel are used for continuous longitudinal members the whole of the topsides and bottom are to be of higher tensile steel so that the section modulus amidships of the hull girder complies with the following requirements:—

At the deck at side: $0,93 \times k_1 \times N \times 10^5$ cm$^3$

At the keel: $k_1 \times N \times 10^5$ cm$^3$

($k_1 = k$ or $0,0625 \frac{L}{D}$ whichever is the greater)

In addition, the section modulus, using the total inertia and with y measured to the extreme ordinary mild steel fibre is not to be less than $N \times 10^5$ at the bottom or $0,93 \times N \times 10^5$ at the top of the mild steel portion of the girder.

**Bulk Carriers**

**6603** The basic modulus M as determined from D 3704 is to be multiplied by the factor k or by $0,0625 \frac{L}{D}$ whichever is the greater. Where both higher tensile steel and ordinary mild steel are used for continuous longitudinal members, the section modulus, using the total inertia and with y measured to the extreme ordinary mild steel fibre should not be less than the normal deck modulus for the class notation.

**Other Ships**

**6604** The required scantlings of the deck and bottom will be specially considered.

## Section 67

### LOCAL STRENGTH

**6701** The requirements of the following paragraphs should be applied to the scantlings of the structural members as determined from the appropriate section of the Rules.

**Shell Plating**

**6702** The thicknesses of side and bottom shell plating (including minima) are to be reduced by the factor $\sqrt{k}$, subject to compliance with longitudinal strength requirements.

**Deck Plating**

**6703** The thickness of deck plating is to be determined by longitudinal strength requirements, and the minimum thickness may be reduced by the factor $\sqrt{k}$.

**Longitudinal Framing**

**6704** The section modulus of deck, side, bottom and inner bottom longitudinals is to be multiplied by the factor k.

**Girders**

**6705** The section modulus of deck and bottom girders is to be multiplied by the factor k.

**Double Bottom**

**6706** The height of the double bottom is to be as required by the appropriate section of the Rules, but the thicknesses of floors, girders and tank top are to be multiplied by the factor $\sqrt{k}$. The factor should be applied to the Rule thickness of tank top plating and the full increase for grab discharge (if applicable) added to this corrected thickness.

*25th July, 1963*

**Bulkheads**

**6707** The section modulus of the stiffeners is to be multiplied by the factor k and the plating thickness by the factor $\sqrt{k}$. Corrugated bulkheads may be similarly treated except that the minimum moment of inertia shall not be reduced.

**Cross Ties**

**6708** The area of cross ties is to be multiplied by the factor k. The least moment of inertia shall not be reduced.

**Minimum Thickness**

**6709** The minimum thickness of structural items is to be reduced by the factor $\sqrt{k}$.

**Riveting**

**6710** Riveting is to be based on a nominal plating thickness equal to:—

$$\frac{\text{H.T. Steel Thickness}}{k}$$

# REQUIREMENTS FOR THE CARRIAGE OF LIQUEFIED GASES

*(The attention of Builders and Owners is directed to the fact that compliance with these Rules may involve the obtaining of licences under existing patents.)*

## Section 70

### GENERAL

#### Class

**7001** The class 100A1 Liquefied Gas Carrier, type of gas(es) in independent tanks, maximum vapour pressure, minimum temperature and, where necessary, maximum temperature (to be specified), will be assigned to ships specially designed for the carriage of liquefied petroleum natural or other gases in separate tanks and built in accordance with, or equivalent to, the relevant sections of the Rules and the requirements in this section in conjunction with D 71 or D 72 as appropriate.

These requirements are primarily intended to apply to ships having machinery aft and built for the carriage of liquefied petroleum or natural gases in separate tanks and special consideration will be given to the requirements necessary for other liquefied gases.

#### Longitudinal Strength

**7002** The required section modulus at deck and keel is to be determined in accordance with D 3704 and D 3705 of the Rules as required therein for the class 100A1. For ships less than 121,9 metres in length k is to be determined from the following Table:—

| Length | k | Length | k |
|---|---|---|---|
| Metres | | Metres | |
| 90 | 0,788 | 110 | 1,231 |
| 95 | 0,894 | 115 | 1,351 |
| 100 | 1,003 | 120 | 1,476 |
| 105 | 1,115 | | |

#### Extent of Midship Scantlings

**7003** The midship scantlings are to be maintained from 0,2L aft of amidships to 0,2L forward of amidships.

#### Grades of Steel

**7004** Where the thickness of plating exceeds 20,5 mm. and the seams and butts are welded, steel of Grade D (*see* P 2, Table II) will generally be required for the following parts of the structure:—

(*a*) Sheerstrake, strength deck stringer and plating, top strake of the longitudinal bulkhead (where fitted), deck longitudinals of the slab type where cut from plates and through brackets for deck longitudinals from 0,2L aft of amidships to 0,2L forward of amidships, but at least 3 metres forward of the bridge front.

Sheerstrake and strength deck stringer and plating in way of poop front.

Any stringer or sheerstrake plating outside these limits which is above 25,5 mm. in thickness.

(*b*) Bottom shell plating to upper turn of bilge, bottom longitudinals of the slab type where cut from plates and through brackets of bottom longitudinals from 0,15L aft of amidships to 0,15L forward of amidships where the length is 152,4 metres and below, and from 0,25L aft of amidships to 0,2L forward of amidships where the length is 213,4 metres and above with intermediate values obtained by interpolation.

Where the bottom plating is required to be of steel of Grade D the keel is also to be of the same grade.

**7005** Strakes of Grade E steel are to be arranged as follows:—

| Length L | | Grade E strakes |
|---|---|---|
| Over | Not Exceeding | |
| Metres | Metres | |
| 167,6 | 198,1 | Sheerstrake |
| 198,1 | — | Sheerstrake |
| | | Bilge Strake |

The Grade E strakes are to extend between 0,2L aft of amidships and 0,2L forward of amidships.

The breadth of such strakes is not to be less than 1525 mm. except that the bilge strake shall not be less than 1830 mm.

The use of riveted seams as an alternative to strakes of Grade E steel will be specially considered.

**7006** For scantlings and arrangements if higher tensile steel is used *see* D 65, D 66 and D 67.

### Double Bottom Structure

**7007** The scantlings of the double bottom structure are to be determined in accordance with D 5. Where wing ballast tanks or floodable cofferdams are common with the double bottom tanks, the scantlings of the tank top shall be determined in accordance with 7013 and 7014.

### Bottom Shell

**7008** The thickness of the bottom shell amidships to upper turn of bilge is to be that necessary to give the required section modulus but is to be not less than:—

(*a*) L = less than 121,9 metres:—

$$\left(\frac{L}{18,6} + 7,62\right) - 0,01\,(915 - s)\text{ mm.}$$

(*b*) L = 121,9 metres and above:—

$$\left(\frac{L}{12,0} + 4,0\right) - 0,01\,(915 - s)\text{ mm.}$$

where L is the length, in metres,

s is the spacing of frames or longitudinals, in mm.

The thickness as determined from these formulæ is applicable to longitudinal framing and where the bottom is transversely framed the thickness is to be increased by 1,5 mm. and, if applicable, the requirements of D 708 are to be complied with.

### Side Shell

**7009** The thickness of the side shell plating is to be determined from Table 14 and associated notes. If the sides are longitudinally framed, the frame spacing correction is to be based upon the spacing of the longitudinals and the tabular spacing in Column 4 of Table 14.

### Transverse Side Framing

**7010** The scantlings of transverse side frames are to be obtained from Table 12 and associated notes. Where an inner hull is provided and the side frames are supported by stringers the required section modulus of the frames is:—

$$\frac{I}{y} = \frac{s \times h \times S^2}{107,5}\text{ cm.}^3$$

where s = frame spacing, in mm.,

h = head, in metres, from mid-point of span to deck at side,

S = span, in metres.

### Longitudinal Side Framing

**7011** The section modulus of side longitudinals is to be not less than:—

$$\frac{I}{y} = \frac{s \times S^2}{117,6}\left\{h + \frac{2,5d - D}{6}\right\}\text{cm.}^3$$

where s = spacing of longitudinals, in mm.,

S = span, in metres, measured between transverses or from transverse to "span point",

h = distance of longitudinal below deck at side, in metres,

d = summer draught measured from top of keel, but not less than 0,4D, in metres.

**7012** Side transverses are to be spaced not more than 3,66 metres apart and the section modulus is to be not less than:—

$$\frac{I}{y} = \frac{s \times h \times S^2}{k}\text{ cm.}^3$$

where s = spacing of transverses, in metres,

S = span of transverses, in metres,

h = head from midpoint of span to deck at side, in metres,

k = $81,6 \times 10^{-3}$ when d/D = 0,75 and above, $94,8 \times 10^{-3}$ when d/D = 0,50 or below, with intermediate values by interpolation.

### Inner Hull

**7013** Where an inner hull is fitted to form wing ballast tanks (*see* D 7102) the thickness of plating is to be not less than:—

$$t = \left(0,26 + \frac{h}{48,8}\right)\frac{s}{30}\text{mm.}$$

where h = distance, in metres, from lower edge of plate to highest point of tank,

s = spacing of stiffeners, in mm.

**7014** The section modulus of horizontal or vertical stiffeners is to be not less than:—

$$\frac{I}{y} = \frac{s \times h \times S^2}{117,6}\text{ cm.}^3$$

where s = spacing, in mm.,

S = span, in metres, measured between girders or from girder to "span point",

h = distance, in metres, from centre of span to highest point of tank, but not less than 1,8 metres.

**7015** The width of the wing tank and the spacing of the side transverses are to be such that the transverses, in association with the effective area of shell and bulkhead plating (*see* D 5303), have a section modulus not less than that given by 7012.

**Decks**

**7016** The thickness of deck plating is to be determined from the requirements of 7002 but is to be not less than the minimum thickness as determined from Tables 18 or 20 and associated notes.

**7017** The scantlings of beams or longitudinals are to be obtained from Tables 24, 25, 26 or 27 and associated notes as appropriate.

**7018** The section modulus of deck transverses is to be not less than:—

$$\frac{I}{y} = \frac{s \times S^2}{13{,}8 \times 10^{-2}} \text{ cm.}^3$$

where s = spacing of transverses, in metres,
S = span of transverses, in metres.

**Transverse Bulkheads**

**7019** The scantlings of single transverse watertight bulkheads are to be determined from Tables 32, 33 and 34 and associated notes.

**7020** Where the transverse bulkheads are arranged as floodable cofferdams (*see* D 7105) the scantlings of the bulkheads are to be in accordance with 7013 and 7014.

**Cross-references**

**7021** For filling, discharging and venting pipe arrangements, *see* E 12.

For electrical installations, *see* M 16.

For refrigerating machinery and arrangements, *see* E 12.

For the use of methane gas as fuel for propulsion purposes, *see* R (A).

## Section 71

### CARRIAGE AT A PRESSURE OF 0,70 kg. per cm.$^2$ GAUGE OR LESS

**Submission of Plans**

**7101** In addition to those required by D 108 the following plans are to be submitted:—

Scantlings of cargo tanks.

Details of tank supports and keying arrangements.

Fire extinguishing arrangements.

The following should also be submitted:—

Calculations for dynamic loading of cargo tanks (*see* 7116).

Specification for tank material including results of low temperature tests.

**Ship's Structure**

**7102** Vessels are to have a double bottom and, where the cargo is to be carried at a temperature below −10° C. (+14° F.), are generally to be provided with two longitudinal bulkheads forming side tanks.

**7103** Cofferdams are to be arranged at each end of the tank space. Other transverse bulkheads are to be arranged as floodable cofferdams when the minimum cargo temperature is below −50° C. (−58° F.).

**7104** When the minimum cargo temperature is below −10° C. (+14° F.) a secondary barrier is to be provided which will act as a temporary containment for the liquefied gas in the event of a leakage from the containers.

Provided the minimum cargo temperature is not below −50° C. (−58° F.) this containment may be provided by the hull structure, but with this arrangement the grades of steel in the containing hull structure are to be dependent on the minimum steel temperatures which may arise in the event of leakage from the cargo tanks, as follows:—

| | |
|---|---|
| Down to −10° C. (+14° F.) ... | ... Grade A |
| −10° C. (+14° F.) to −30° C. (−22° F.) | ... Grade D |
| −30° C. (−22° F.) to −50° C. (−58° F. | ... Grade E |

**7105** The insulation arrangements are to be such that the minimum steel temperature in the hull structure adjacent to the cargo tanks does not fall below the following values when the cargo tanks are at the minimum service temperature and the air temperature is 5° C. (+41° F.):—

| | |
|---|---|
| Grade A ... | 0° C. (+32° F.) |
| Grade D ... | −12° C. (+10° F.) |
| Grade E ... | −18° C. (0° F.) |

**7106** Where a secondary barrier separate from the hull structure is provided the following requirements are to be met:—

(*a*) The minimum hull steel temperatures, in the event of leakage from the cargo tanks, shall not be less than those given in 7104 for the particular grade of steel.

(*b*) Thermo-couples are to be arranged on the ship's structure adjacent to the cargo tanks and the

arrangements are to be such as to give continuous temperature readings and audible warning of the development of temperatures lower than given in 7104. In general, such thermo-couples are to be arranged not more than 6,1 metres apart.

(*c*) The extent of the secondary barrier is to be such that the liquefied gas will not come into contact with the hull structure in the event of failure of one cargo tank with the ship heeled to an angle of 30°.

(*d*) The secondary barrier shall be capable of containing the liquefied gas for a period of at least 14 days.

**7107** Arrangements are to be provided to enable the double bottom, wing tank spaces and all transverse coffer-dams (where fitted) to be flooded in the event of leakage from the cargo tanks.

**7108** Suitable arrangements are to be made for sealing the weather deck in way of openings for the cargo tanks.

**7109** Any means of access to the spaces around the cargo tanks is to be from above the weather deck.

**7110** The spaces containing the cargo tanks are to be permanently filled with an inert gas and a monitoring system is to be installed to ensure that any leakage from the tank is immediately detected.

**7111** Arrangements are to be provided to prevent excessive pressure coming on to the containment spaces either during service or in the event of leakage from the cargo tanks.

**Cargo Tanks**

**7112** The material to be used in the construction of the cargo tanks must have suitable mechanical properties at the service temperature. Particulars of the material proposed are to be submitted for approval.

**7113** Where a ferritic steel is to be used, tensile, bend and Charpy V-notch impact test pieces are to be prepared from each plate or section. The dimensions of the test pieces are to be in accordance with the requirements contained in P 203, P 204, P 206 and P 207.

The results of the tensile and bend tests are to comply with the approved specification. For the Charpy V-notch impact tests the "required temperature" is the lowest service temperature and the results of the tests are to give an average energy for fracture of not less than 5,53 kg.m.

Other criteria and methods of testing will be accepted where considered equivalent to the above requirements.

**7114** It is to be demonstrated by procedure tests that the proposed methods of welding are satisfactory and produce sound welds. Charpy V-notch impact test pieces are to be prepared from butt welded test plates and are to be notched in the heat-affected zone and, if the deposited metal is a ferritic steel, further test pieces are to be notched in the weld. Unless otherwise approved, the results of the impact tests on these test pieces at the minimum temperature of service are to be not less than those specified for the parent material.

**7115** For materials other than ferritic steels, the proposed material specification is to be submitted. The notched properties as determined by suitable tests and/or evidence of comparable service experience, at temperatures lower than or equal to the minimum service temperature are also to be submitted, together with corresponding data on the weld metal and heat-affected zone.

**7116** The tanks shall be designed to withstand:—

(i) A test head of 2,44 metres of water above the top of the tank or 0,61 metres above the top of the hatch, whichever may be the greater.

(ii) The combined effect of internal vapour pressure (if any) and rolling, pitching and heaving as follows:—

(1) A complete 30° roll port and starboard (i.e. through 120°) in a period of ten seconds.

(2) A pitch of 6° half amplitude in a pitch period of seven seconds (i.e. through 24° in seven seconds).

(3) A heave of L/80 metres half amplitude in a period of eight seconds (i.e. through L/20 metres in eight seconds).

With the loading determined in accordance with the above, the stress in any item shall not exceed three-quarters of the yield stress or three-eighths of the ultimate stress.

**7117** Means are to be provided to prevent excessive pressure coming on to the tanks (*see* E 12).

**7118** The tanks are to be supported on substantial foundations arranged to avoid excessive concentration of load on the ship's structure or on the tank. Provision is to be made for the thermal contraction of the tanks on cooling from ambient to service temperature and arrangements are to be made to control the movement of the tanks when the vessel is rolling and pitching.

**7119** The arrangement of tanks and insulation is to be such that at least one side of the tank plating and adjacent hull structure is readily accessible for inspection.

**7120** During the construction of the tanks all butt welds are to be radiographed.

**7121** The tanks are to be tested on completion with a head of water in accordance with 7116 (i).

**7122** Thermo-couples are to be fitted to at least one tank to enable a satisfactory pre-cooling procedure to be established unless other satisfactory arrangements can be made.

**Insulation**

**7123** The insulation is to be of an approved type and of sufficient thickness to comply with 7105 of these requirements. It is to be suitable for the loads imposed and adequately protected against penetration of water vapour from the atmosphere.

Particulars of the insulating material(s) and the estimated heat conductivity value(s) at the service conditions are to be supplied, together with the proposed thickness(es) and methods of fitting, jointing and sealing the insulation.

## Section 72

### CARRIAGE AT A PRESSURE ABOVE 0,70 kg. per cm.$^2$ GAUGE (WITH OR WITHOUT REFRIGERATION PLANT)

**Submission of Plans**

**7201** In addition to those required by D 108 the following plans are to be submitted:—

Cargo Tank Seatings and Securing Arrangements.
Hold Ventilation System.
Fire Extinguishing Arrangements.

**Ship's Structure**

**7202** Where the cargo is to be carried at a temperature below ambient the requirements of D 7104 and D 7105 are to be complied with.

**7203** Cofferdams, or single bulkheads of all-welded construction forming an "A" class fire-resisting division, are to be arranged between spaces containing the cargo tanks and machinery spaces.

**Installation of Cargo Tanks**

**7204** Cargo tanks are to be sited so that the following minimum clearances are obtained:—

(*a*) Tanks to the side shell—generally 610 mm., but clearances at the ends of the ship below the load waterline will be specially considered.

(*b*) Tanks to inner bottom plating—150 mm.

(*c*) Tanks to bottom shell (if no inner bottom is fitted)—the dimension given in Table 6, Col. 4 (without correction for draught).

Where more than one tank is fitted in a space, sufficient clearance is to be left between tanks for inspection or repairs and in no case less than 300 mm.

**7205** Cargo tank seatings and securing arrangements are to be suitable for dynamic loading to the extent given in D 7116 and should also be suitable for the forces arising when a cargo hold is flooded with the cargo tanks empty. Seatings are to be designed to ensure uniform support to the pressure vessel having due regard to deflections of the hull structure in a seaway. When the cargo is to be carried at temperatures below ambient, provision is to be made for expansion and contraction.

**7206** The supports and securing arrangements should also be capable of withstanding a longitudinal acceleration of 0,5 g.

**7207** Suitable arrangements are to be made for sealing the weather deck in way of openings for the cargo tanks.

**7208** The spaces containing the cargo tanks are to be provided with means for access from above the weather deck.

**7209** Ventilation systems for the spaces containing cargo tanks are to be independent of other ventilation systems, and means are to be provided to enable any single compartment to be isolated. Details, including the positioning of exhaust outlets, are to be submitted.

**7210** Means are to be provided to enable the air in the cargo tank spaces, pump and compressor rooms to be sampled to detect any leakage.

**Cross-reference**

**7211** For cargo tanks and their mountings *see* J 25 and E 12.

*21st May, 1964*

# Chapter E

# PUMPING AND PIPING

## Section 1

### PLANS

**101** The following plans are to be submitted for consideration:—

General pumping arrangements, including air and sounding pipes and any cross flooding pipes and fittings. (Shipbuilder's plan.)

Pumping arrangements at the forward and after ends of oil tankers and drainage of cofferdams and pump rooms.

General arrangement of cargo piping in tanks and on deck of oil tankers.

Piping arrangements for cargo oil (F.P. above 65,5° C.).

Bilge, ballast and oil fuel pumping arrangements in the machinery space, including the capacities of the pumps on bilge service. In the case of passenger ships the criterion numeral, as defined in the International Convention for the Safety of Life at Sea–1960 is to be stated together with the number of flooded compartments which the ship is required to withstand under damage conditions.

Arrangement of oil fuel pipes and fittings at settling and service tanks.

Arrangements of oil fuel piping in connection with oil burning installations and oil fired galleys.

Oil fuel and cargo oil overflow systems, where these are fitted.

Arrangement of boiler feed system.

Oil fuel settling, service and other oil fuel tanks not forming part of the ship's structure.

Above plans of machinery space piping are to be diagrammatic.

Arrangement and dimensions of main steam pipes with details of flanges, bolts and weld attachments and particulars of the material of pipes, flanges bolts and electrodes.

NOTE.—Plans additional to the above should not be submitted unless the arrangements are of a novel or special character affecting classification.

*See* G 111 for centralised or automatic controls to tanker pumping systems.

*See* Chapter R(D) for Guidance Notes on Metal Pipes for Water Services.

## Section 2

### GENERAL

**201** In power driven ships the pumping arrangements according to the division of compartments, rise of floor and other conditions are to be as detailed in these Rules which apply to passenger ships, cargo and other ships except where otherwise stated.

**202** While the arrangements satisfy the requirements of the International Convention for the Safety of Life at Sea–1960, attention should be given to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered.

**203** The Committee will be prepared to give consideration to special cases or to arrangements which are fully equivalent to those required by these Rules. Consideration will also be given to the pumping arrangements of small ships and ships to be assigned class notations for restricted or special services.

(For pumping arrangements of non-propelled ships, *see* E 10.)

### BILGE AND BALLAST

**204** All ships are to be provided with efficient pumping plant having the suctions and means for drainage so arranged that any water within any compartment of the ship, or any watertight section of any compartment, can be pumped out through at least one suction when the ship is on an even keel and is either upright or has a list of not more than 5 degrees. For this purpose wing suctions will generally be necessary, except in short, narrow compartments where one suction can provide effective drainage under the above conditions.

In passenger ships the pumping plant is to be capable of draining any watertight compartment under all practical conditions after a casualty, whether the ship is upright or listed.

#### Hold Drainage

**205** In ships having only one hold, and this over 33,5 metres in length, bilge suctions are to be fitted in suitable positions in the after half-length. also in the forward half-length of the hold.

**206** Where close ceiling or continuous gusset plates are fitted over the bilges, arrangements are to be made whereby water in a hold compartment may find its way to the suction pipes.

**207** Where the inner bottom plating extends to the ship's side, the bilge suctions are to be led to wells placed at the wings. If the tank top plating has inverse camber, a well is also to be fitted at the centre line.

Bilge wells are to be formed of steel plates and are to be of not less than 0,17 cubic metre capacity. In small compartments, steel bilge hats of reasonable capacity may be fitted.

In passenger ships wells in double bottom tanks are not to extend downwards more than necessary; the depth of the well is in no case to be more than the depth less 460 mm. of the double bottom at the centre line, nor shall the well extend below the horizontal plane referred to in D 526.

Where access manholes to bilge wells are necessary, they are to be fitted as near to the suction strums as practicable.

**208** Access to the bilge suction strum of a hold well should not be obtained by means of a manhole in the machinery space watertight bulkheads or tank top plating in the machinery space or tunnel if this can be avoided.

Where, however, this arrangement is necessary, the watertight manhole cover should be of hinged type and an instruction plate, in raised letters, should be affixed in a well lighted position, to the effect that this door must be kept shut, except when access is required. In passenger ships these arrangements are not permissible.

**209** The intactness of the machinery space bulkheads, and of tunnel plating which is required to be of watertight construction, is not to be impaired by the fitting of scuppers discharging to machinery space or tunnels from adjacent compartments which are situated below the bulkhead deck.

These scuppers may, however, be led into a strongly constructed scupper drain tank situated in the machinery space or tunnel but closed to these spaces and drained by means of a suction of appropriate size led from the main bilge line through a screw-down non-return valve.

The tank air pipe is to be led to above the bulkhead deck and provision is to be made for ascertaining the level of water in the tank.

Where one tank is used for the drainage of several watertight compartments, the scupper pipes are to be provided with screw-down non-return valves.

**210** Steering gear compartments or other small enclosed spaces situated above the after peak tank are to be provided with suitable means of drainage either by hand or power pump bilge suctions.

If, however, these compartments are adequately isolated from the adjacent 'tween decks, they may be drained by scuppers not less than 38 mm. bore, discharging to the tunnel and fitted with self-closing cocks situated in well lighted and visible positions. These arrangements are not applicable to passenger ships unless specially approved in relation to sub-division considerations.

### Drainage from Refrigerated Cargo Spaces

**211** Provision is to be made for the continuous drainage of the inside of all insulated chambers and cooler trays.

**212** Drains which are led from lower holds and cooler trays situated on the tank top are to be fitted with liquid sealed non-return bilge traps.

Drains from 'tween deck chambers and from cooler trays which are situated well above the tank top are also to be fitted with liquid sealed traps, but the non-return valves may be omitted if desired. (For insulation of scupper pipes, *see* E 418.)

**213** Where drains from separate chambers join a common main, the branch pipes are each to be provided with a liquid sealed trap.

**214** The liquid sealed traps are to be of adequate depth and arrangements are to be made for ready access to the traps for cleaning and refilling with brine.

**215** Sluices, scuppers or drain pipes which would permit drainage from compartments outside the insulated chambers into the bilges of the latter are not to be fitted.

**216** Screwed plugs or other means for blanking off scuppers draining insulating chambers and cooler trays are not to be fitted.

If, however, it is specially desired by the Owners to provide means for temporarily closing these scuppers, they may be fitted with shut-off valves controlled from readily accessible positions on a deck above the load water line.

### Machinery Space—Bilge Drainage

**217** The bilge drainage arrangements in the machinery space are to be such that any water which may enter this compartment can be pumped out through at least two bilge suctions when the ship is on an even keel and is either upright or has a list of not more than 5 degrees. One of

these suctions is to be a branch bilge suction, i.e., a suction connected to the main bilge line, and the other is to be led direct from an independent power pump. Examples of the necessary arrangements are detailed in 218 to 220.

In passenger ships the drainage arrangements are to be such that machinery spaces can be pumped out under all practical conditions after a casualty whether the ship is upright or listed.

**218** Where the double bottom extends the full length of the machinery space and forms bilges at the wings, it will be necessary to provide one branch and one direct bilge suction at each side.

**219** Where the double bottom plating extends the full length and breadth of the compartment, one branch bilge suction and one direct bilge suction are to be led to each of two bilge wells of not less than 0,17 cubic metre capacity, situated one at each side.

In passenger ships the depth of bilge wells is to comply with the requirements of 207.

**220** Where there is no double bottom and the rise of floor is not less than 5 degrees, one branch and one direct bilge suction are to be led to accessible positions as near the centre line as practicable.

In ships where the rise of floor is less than 5 degrees and in all passenger ships additional bilge suctions are to be provided at the wings.

**221** Additional bilge suctions may be required for the drainage of depressions in the tank top formed by crank pits, or other recesses, by tank tops having inverse camber or by discontinuity of the double bottom.

**222** In ships in which the propelling machinery is situated at the after end of the ship, it will generally be necessary for bilge suctions to be fitted in the forward wings as well as the after end of the machinery space, but each case will be dealt with according to the size and structural arrangements of the compartment.

**223** In ships propelled by electrical machinery, special means are to be provided to prevent the accumulation of bilge water under the main propulsion generators and motors.

**224** Where the machinery space is divided by watertight bulkheads to separate the boiler room(s) or auxiliary engine room(s) from the main engine room, the number and position of the branch bilge suctions in the boiler room(s) and auxiliary engine room(s) are to be the same as for cargo holds.

In addition to the branch bilge suctions an independent power pump direct bilge suction is to be fitted in each compartment. Similar provision is to be made in separate motor rooms of electrically propelled ships.

**225** In passenger ships each independent bilge pump is to have a direct bilge suction from the space in which it is situated, but not more than two such suctions are required in any one space. Where two or more such suctions are provided there is to be at least one suction on each side of the space.

**Machinery Space—Emergency Bilge Drainage**

**226** In steamers, the main circulating water pump to each main engine is to be fitted with an emergency bilge suction, i.e., "bilge injection", which is to be additional to the bilge suctions detailed in 217 to 225. This suction, which is to have a diameter of at least two-thirds that of the pump suction, is to be led to a suitable low level in the machinery space and is to be fitted with a screw-down non-return valve having the spindle so extended that the hand-wheel is not less than 457 mm. above the bottom platform.

If two pumps are provided for one engine, each capable of supplying sufficient cooling water for normal power, only one pump need be fitted with an emergency bilge suction.

In coal-burning steamships a flexible bilge hose is to be provided for connecting to the independent power bilge pump. The hose is to have an internal diameter of 102 mm. or that required for the main bilge line, whichever is the less, and is to be of sufficient length to reach any part of the engine and boiler room bilges into which coal or ashes could be washed. The lower end of the hose is to be provided with a strainer.

The hose fitting on the pump is to comply with the requirements of 246.

Where main circulating water pumps are not suitable for bilge pumping duties, alternative arrangements may be submitted for consideration.

**227** In motorships, the emergency bilge suction is to be led to the main cooling water pump or to the main cooling water suction line. The suction is to be of the same size as the suction branch of the cooling water pump and the valve nameplate is to be marked "For emergency use only".

Alternatively, the emergency bilge suction may be led to the largest available power pump which is not fitted with a direct bilge suction and is to be of the same size as the suction branch of the pump. This pump is to have a capacity greater than that required for a bilge pump, and if it is of the self-priming type the direct bilge suction on the same side of the ship as the emergency suction may be omitted, except in passenger ships.

### Tunnel Drainage

**228** The tunnel well is to be drained by a suction from the main bilge line. In all ships including passenger ships this well may extend to the outer bottom.

**229** Where the tank top in the tunnel slopes down from aft to forward, a bilge suction is to be provided at the forward end of the tunnel, in addition to the tunnel well suction required by 228.

### Sizes of Bilge Suction Pipes

**230** The diameters of bilge suction pipes are to be not less than required by the following formulæ, to the nearest 5 mm.:—

Main Bilge Line

$$d_m = 26 + \sqrt{2{,}78\, L\,(B + D)} \qquad (a)$$

In no case is the diameter of the main bilge line to be less than required for any branch bilge suction.

Branch Bilge Suctions to Cargo and Machinery Spaces

$$d_b = 26 + \sqrt{4{,}63C\,(B+D)} \qquad (b)$$

where $d_m$ = internal diameter of main bilge line, in millimetres,

$d_b$ = internal diameter of branch bilge suction, in millimetres,

$L$ = Rule length of ship, in metres,

$B$ = Rule breadth of ship, in metres,

$D$ = moulded depth to bulkhead deck, in metres,

$C$ = length of compartment, in metres.

No bilge suction pipe is, however, to be less than 50 mm. bore.

Direct Bilge Suctions, other than Emergency Suctions

**231** The direct bilge suctions in the main engine room and the direct bilge suctions in large separate boiler rooms, motor rooms of electrically propelled ships and auxiliary engine rooms are to be of a diameter not less than required for the main bilge line.

Where the separate machinery spaces are of small dimensions, the sizes of the direct bilge suctions to these spaces will be specially considered.

For sizes of emergency bilge suctions, *see* 226 and 227.

**232** In oil tankers and similar ships where the engine room pumps do not deal with bilge drainage outside the machinery space, the diameter of the main bilge line may be less than required by 230, formula (*a*), provided the cross-sectional area is not less than twice that required for the branch bilge suctions in the machinery space.

**233** The area of each branch pipe connecting the bilge main to a bilge distribution chest is to be not less than the sum of the areas required by the Rules for the two largest branch bilge suction pipes connected to that chest, but need not be greater than that required for the main bilge line.

**234** The bilge suction pipe to the tunnel well is to be not less than 65 mm. bore, except in ships not exceeding 61 metres in length, in which case it may be 50 mm. bore.

### Bilge and General Service Pumps

**235** For ships other than passenger ships at least two power bilge pumping units are to be provided in the machinery space. In ships of 91,5 metres in length and under, one of these units may be worked from the main engines and the other is to be independently driven. In larger ships both units are to be independently driven.

Each of these units is to be connected to the main bilge line and is to be capable of giving a speed of water through the Rule size of bilge line of not less than 122 metres per minute under ordinary working conditions, but where one unit is of slightly less than this capacity, the deficiency may be made good by an excess capacity of the other unit.

**236** Table of Capacities

| Bore of bilge pipe | | Capacity of each pumping unit in metres³/hour | Bore of bilge pipe | | Capacity of each pumping unit in metres³/hour |
|---|---|---|---|---|---|
| Ins. | Metric equivalent in mm. | | Ins. | Metric equivalent in mm. | |
| 2 | 51 | 15 | 5¼ | 133 | 103 |
| 2¼ | 57 | 19 | 5½ | 140 | 113 |
| 2½ | 63,5 | 23 | 5¾ | 146 | 124 |
| 2¾ | 70 | 28 | 6 | 152 | 135 |
| 3 | 76 | 34 | 6¼ | 159 | 146 |
| 3¼ | 82,5 | 40 | 6½ | 165 | 158 |
| 3½ | 89 | 46 | 6¾ | 171 | 171 |
| 3¾ | 95 | 53 | 7 | 178 | 183 |
| 4 | 102 | 60 | 7¼ | 184 | 197 |
| 4¼ | 108 | 68 | 7½ | 190 | 210 |
| 4½ | 114 | 76 | 7¾ | 197 | 224 |
| 4¾ | 121 | 84 | 8 | 203 | 239 |
| 5 | 127 | 93 | 8¼ | 209 | 254 |

**237** Each unit may consist of one or more pumps connected to the main bilge line, provided their combined capacity is adequate.

**238** In ships other than passenger ships a bilge ejector in combination with a high pressure sea water pump may be accepted as a substitute for an independent bilge pump required by 235.

**239** For passenger ships at least three power bilge pumps are to be provided, one of which may be operated from the main engines. Where the criterion numeral is 30 or more, one additional independent power pump is to be provided. A main engine driven pump may be replaced by an independent pump. Each pump is to be connected to the main bilge line and is to be capable of giving a speed of water through the Rule size of main bilge pipe of not less than 122 metres per minute.

For location of pumps, *see* 256.

### Self-Priming Pumps

**240** All power pumps which are essential for bilge services are to be of self-priming type, unless an approved central priming system is provided for these pumps. Details of this system are to be submitted.

Cooling water pumps having bilge ejection connections need not be of self-priming type.

### Pump Connections

**241** The connections at the bilge pumps are to be such that one unit may continue in operation when the other unit is being opened up for overhaul.

**242** Pumps required for essential services are not to be connected to a common suction or discharge chest or pipe unless the arrangements are such that the working of any of the pumps so connected is unaffected by the other pumps being in operation at the same time.

### Direct Bilge Suctions

**243** The direct bilge suctions in the machinery space(s) are to be led to independent power pump(s), and the arrangements are to be such that these direct suctions can be used independently of the main bilge line suctions.

### Main Bilge Line Suctions

**244** Suctions from the main bilge line, i.e., branch bilge suctions, are to be arranged to draw water from any hold or machinery compartment of the ship, excepting small spaces such as those mentioned in 262, where manual pump suctions are accepted, and are to be of not less size than required by 230, formula (*b*). (For special arrangements for oil tankers, *see* E 1112 to E 1117).

### Pipe Systems and their Fittings

**245** The arrangement of valves, cocks and their connections is to be such as to prevent the possibility of one watertight compartment being placed in communication with another, or of dry cargo spaces, machinery spaces or other dry compartments being placed in communication with the sea or with tanks.

To effect this requirement, the bilge connections to any pump having also suctions from the sea and from tanks should be made either by means of non-return valves or cocks which cannot permit communication between the bilges and the sea or compartments in use as tanks.

**246** Screw-down non-return valves are to be provided in the following fittings:—

Bilge valve distribution chests;

Bilge suction hose connections, whether fitted direct to the pump or on the main bilge line;

Direct bilge suctions and bilge pump connections to main bilge line.

**247** Bilge pipes which are required for draining cargo or machinery spaces are to be entirely distinct from sea inlet pipes or from pipes which may be used for filling or emptying spaces where water or oil is carried. This does not, however, exclude a bilge ejection connection, a connecting pipe from a pump to its suction valve chest, or a deep tank suction pipe suitably connected through a change-over device to either a bilge, ballast or oil line.

**248** Suctions for bilge drainage in machinery spaces and tunnels, other than emergency suctions, are to be led from easily accessible mud boxes fitted with straight tail pipes to the bilges and having covers secured in such a manner as to permit of their being expeditiously opened or closed. Strum boxes are not to be fitted to the lower ends of these tail pipes.

**249** The open ends of bilge suctions in holds and other compartments outside machinery spaces and tunnels, are to be enclosed in strum boxes having perforations not more than 10 mm. diameter, whose combined area is not less than twice that required for the suction pipe. The boxes are to be so constructed that they can be cleared without breaking any joint of the suction pipe.

The distance between the foot of all bilge tail pipes and the bottom of the bilge or well is to be adequate to allow a full flow of water and to facilitate cleaning.

**250** All cocks and valves in connection with bilge, ballast and fresh water suction pipes are to be fitted with legible nameplates, and, unless otherwise specifically mentioned in the Rules, are to be fitted in places where they are at all times readily accessible.

**251** Bilge cocks, valves and mud boxes are to be fitted at, or above, the machinery space and tunnel platforms.

Where it is not practicable to avoid the fittings being situated at the starting platform or in passageways, they may be situated just below the platform, provided readily removable traps or covers are fitted and nameplates indicate the presence of these fittings.

If relief valves are fitted to pumps having sea connections, these valves are to be fitted in readily visible positions above the platform.

**252** Bilge suction pipes are not to be carried through double bottom tanks if it is possible to avoid doing so.

Bilge pipes which pass through these tanks are to be of substantial strength and are to be tested, after fitting, to the same pressure as the tanks through which they pass.

**253** In way of deep tanks for water ballast, fresh water, oil fuel or cargo oil, bilge pipes should preferably be led through pipe tunnels but, where this is not done, the pipes are to be of steel of heavy gauge with welded joints or heavy flanged joints. The number of joints is to be kept to a minimum.

Expansion bends, not glands, are to be fitted to these pipes within the tanks, and the open ends of the bilge suction pipes in the holds are to be fitted with non-return valves of the special type approved for use in holds (*see* 266).

Tank piping, other than that of the deep cargo tank pumping system, is not to be situated within deep cargo oil tanks.

The pipes are to be tested, after fitting, to a pressure not less than the maximum head to which the tanks can be subjected.

**254** Bilge, ballast and cooling water suction and discharge pipes are to be permanent pipes made in readily removable lengths with flanged joints, except as mentioned in 253, and are to be efficiently secured in position to prevent chafing or lateral movement.

Long or heavy lengths of pipes are to be supported by bearers so that no undue load is carried by the flanged connections of the pumps or fittings to which they are attached.

Where lack of space prevents the use of normal circular flanges, details of the alternative methods of joining the pipes are to be submitted.

Pipes for the bilge and ballast systems are to be made of cast or wrought iron, steel, copper or other approved material. Heat sensitive materials such as lead are not to be used.

**255** Suitable provision for expansion is to be made in each range of pipes.

### Bilge Drainage and Cross Flooding Arrangements for Passenger Ships in Damaged Condition

**256** In passenger ships the power bilge pumps are, if practicable, to be placed in separate watertight compartments which will not readily be flooded by the same damage. If the engines and boilers are in two or more watertight compartments, the bilge pumps are to be distributed throughout these compartments as far as possible.

In passenger ships of 91,5 metres or more in length or having a criterion numeral of 30 or more, the arrangements are to be such that at least one power pump will be available for use in all ordinary circumstances in which the ship may be flooded at sea. This requirement will be satisfied if:—

(*a*) One of the pumps is an emergency pump of a submersible type having a source of power situated above the bulkhead deck or,

(*b*) The pumps and their sources of power are so disposed throughout the length of the ship that, under any conditions of flooding which the ship is required by statutory regulation to withstand, at least one pump in an undamaged compartment will be available.

**257** The bilge main is to be arranged so that no part is situated nearer the side of the ship than $\frac{B}{5}$ where B is the breadth of the ship.

Where any bilge pump or its pipe connection to the bilge main is situated outboard of the $\frac{B}{5}$ line then a non-return valve is to be provided in the pipe connection at the junction with the bilge main. The emergency bilge pump and its connections to the bilge main are to be arranged so that they are situated inboard of the $\frac{B}{5}$ line.

**258** Provision is to be made to prevent the compartment served by any bilge suction pipe being flooded in the event of the pipe being severed, or otherwise damaged by collision or grounding in any other compartment. For this purpose, where the pipe is at any part situated nearer the side of the ship than $\frac{B}{5}$ or in a duct keel, a non-return valve is to be fitted to the pipe in the compartment containing the open end.

**259** All the distribution boxes, cocks and valves in connection with the bilge pumping arrangements are to be so arranged that, in the event of flooding, one of the bilge pumps may be operative on any compartment. If there is only one system of pipes common to all pumps, the necessary cocks or valves for controlling the bilge suctions must be capable of being operated from above the bulkhead deck. Where in addition to the main bilge pumping system an emergency bilge pumping system is provided, it is to be independent of the main system and so arranged that a pump is capable of operating on any compartment under flooding conditions; in this case only the cocks and valves necessary for the operation of the emergency system need be capable of being operated from above the bulkhead deck.

**260** All cocks and valves mentioned in the foregoing paragraphs which can be operated from above the bulkhead deck are to have their controls at their place of operation clearly marked and provided with means to indicate whether they are open or closed.

**261** Where divided deep tanks or side tanks are provided with cross flooding arrangements to limit the angle of heel after side damage, the arrangements are either to be self acting or controlled from above the bulkhead deck.

### Fore and After Peak Drainage

**262** Where the peaks are used as tanks, a separate power pump suction is to be led to each tank, except in the case of small tanks used for the carriage of domestic fresh water, when hand pumps may be used.

Where the peaks are not used as tanks and main bilge line suctions are not fitted, drainage of both peaks may be effected by hand pump suctions, provided the suction lift be well within the capacity of the pumps and in no case exceeds 7,3 metres.

Provision is to be made for the drainage of the chain locker and the watertight flat above the fore peak tank by hand or power pump suction. (For drainage of the flat above the after peak tank, *see* 210.)

Where a suction pipe is led from the engine room to the fore peak, either through a hold space or through a tank intended to carry oil fuel, it is to be provided with a screw-down valve capable of being operated from an accessible position above the bulkhead deck, the chest being secured to the collision bulkhead inside the fore peak. An indicator is to be provided to show whether the valve is open or shut.

### Watertight Bulkhead and Tunnel Fittings

**263** No drain valve or cock is to be fitted to the collision bulkhead.

Drain valves or cocks are not to be fitted to other watertight bulkheads, if alternative means of drainage are practicable.

Where fitted, the valves and cocks are to be at all times readily accessible and are to be capable of being shut off from positions above the bulkhead deck. Indicators are to be provided to show whether the drains are open or shut. These arrangements are not permissible in passenger ships. (For drainage of stern compartments, *see* 210.)

**264** Valve chests, cocks, pipes or other fittings attached direct to the plating of tanks, and to bulkheads, flats or tunnels which are required to be of watertight construction, are to be secured by means of studs screwed through the plating or by tap bolts and not by bolts passing through clearance holes.

Alternatively, the studs or the bulkhead piece may be welded to the plating.

### Deep Tanks

**265** In the case of deep tanks which may be used for either water ballast or dry cargo, provision is to be made for blank flanging the water ballast filling and suction pipes when the tank is being used for the carriage of dry cargo and for blank flanging the bilge suction pipes when the tank is being used for the carriage of water ballast.

Change-over devices may be used for this purpose. (For arrangements when oil fuel or cargo oil is carried in deep tanks, *see* E 324.)

### Hold Bilge Valves

**266** Where non-return valves are fitted to the open ends of bilge suction pipes in cargo holds in order to decrease the risk of flooding, they are to be of an approved type which does not offer undue obstruction to the flow of water.

### Ship Side Valves (other than those on Scuppers and Sanitary Discharges)

**267** All sea inlet and overboard discharge pipes are to be fitted with valves or cocks secured direct to the shell plating or to the plating of fabricated steel water boxes attached to the shell plating. These fittings are to be secured by bolts tapped into the plating and fitted with countersunk heads or by studs screwed into heavy steel pads fitted to the plating. The stud holes are not to penetrate the plating.

Distance pieces of short rigid construction, and made of approved material as required by 270, may be fitted between the valves and shell plating. Distance pieces of steel may be welded to the shell plating. Details of the welded connections and of fabricated steel water boxes are to be submitted.

**268** All suction and discharge valves and cocks direct on the shell plating of the ship are to be fitted with spigots passing through the plating, but the spigots on the valves or cocks may be omitted if these fittings are attached to pads or distance pieces which themselves form spigots in way of the shell plating.

Blow-down cocks or valves are also to be fitted with a protection ring through which the spigot is to pass, the ring being on the outside of the shell plating.

Blow-down cocks or valves on the ship's side are to be fitted in accessible positions above the level of the working platform and are to be arranged so that it can be readily seen whether they are open or shut. Cock handles are not to be capable of being removed unless the cocks are shut, and if valves are fitted, the wheels are to be fixed to the spindles.

**269** Sea inlet and overboard discharge cocks and valves are in all cases to be fitted in easily accessible positions and, as far as practicable, are to be readily visible.

Provision is to be made for preventing any discharge of water into lifeboats.

The inlet valve spindles are to extend above the lower platform, and the hand wheels of the main injection and bilge injection valves are to be situated not less than 460 mm. above this platform.

**270** Where valves or cocks are over 75 mm. bore, they are to be of steel or an approved grade of cast iron or other approved material; this requirement applies equally to inlet chests, distance pieces, and other sea connections.

All these fittings, if made of steel, are to be suitably protected against wastage.

**271** The scantlings of valves and valve stools fitted with steam or compressed air clearing connections are to be suitable for the maximum pressure to which the valves and stools may be subjected.

Cross-reference

**272** For sea connections for ships having notation for ice navigation, *see* H 808 to H 810.

Miscellaneous Requirements

**273** All pipes situated in cargo spaces, coal bunkers, chain lockers or other positions where they are liable to mechanical damage are to be efficiently protected. (*See* D 2519, quoted at end of this Section, and D 2412, quoted at end of E 4.)

**274** Wash deck pipes and discharge pipes from the pumps to domestic water tanks are not to be led through cargo holds if, as is generally the case, it is practicable to avoid doing so. Any proposed departure from this requirement is to be submitted.

**275** As far as practicable, pipe lines, including exhaust pipes from oil engines, are not to be led in the vicinity of switchboards or other electrical appliances in positions where drip or escape of liquid, gas or steam from joints or fittings may cause damage to the electrical installation.

Where it is not practicable to comply with these requirements, drip trays or shields are to be provided as found necessary.

Short sounding pipes to tanks should not terminate near electrical appliances (*see* E 413).

## Extract from Chapter D for reference

Scuppers

**D 2508** Scuppers sufficient in number and size to provide effective drainage are to be fitted in all decks.

**D 2509** When the weather deck stringer angle is cut in way of scuppers compensation is to be provided.

**D 2510** Scupper pipes which drain spaces below the freeboard deck are to be led to the bilges, or may be led overboard provided the spaces drained are above the load waterline and the scuppers are fitted with screw-down non-return valves capable of being operated from a position always accessible and above the freeboard deck. Means are to be provided for showing whether the valves are open or closed.

**D 2511** Scuppers draining spaces in intact superstructures or in superstructures having the openings in the end bulkheads closed by strong hinged steel doors may be led to the bilges or may be led overboard and fitted if considered necessary with screwdown non-return valves as required by 2510.

**D 2512** Scuppers draining spaces in short superstructures having the openings in the end bulkheads closed by appliances as described in D 2301 are to be led overboard, with the exception of the scuppers above the machinery space which may be led to the bilges where the lower ends of the pipes are to be visible and readily accessible.

**D 2513** Scuppers which drain overboard from spaces referred to in 2511 and 2512 and which are not required to have storm valves with positive means of control are to be fitted with non-return valves of automatic type.

**D 2514** Scuppers draining spaces in long superstructures having the openings in the end bulkheads closed by appliances as described in D 2301 are, within the range of the machinery space, to be led to the bilges where the lower ends of the pipes are to be visible and readily accessible.

Where additional scuppers are required to ensure effective drainage of the spaces clear of the machinery space these scuppers are to be led to the hold bilges and fitted with screw-down valves at the freeboard deck, the valves being controlled from a position which is accessible at all times above the freeboard or superstructure deck. Means are to be provided for showing whether the valves are open or closed.

**D 2515** Plans showing the arrangement of scuppers for draining refrigerated cargo compartments are to be submitted for consideration.

### Sanitary Discharges

**D 2516** Sanitary discharges from spaces below the freeboard deck are to be provided with efficient and accessible means of preventing water from passing inboard.

Each discharge is to have a screw-down automatic non-return valve operated from an accessible position above the freeboard deck. Means are to be provided for showing whether the valve is opened or closed.

Alternatively, two automatic non-return valves, without positive means of closing, may be fitted provided the upper valve is in a position which is always accessible for examination.

**D 2517** Discharges from spaces within enclosed superstructures are each to be fitted with automatic non-return valves, but arrangements similar to those described in 2516 may be required.

### Materials for Valves and Pipes

**D 2518** Castings enclosing non-return valves are to be of substantial construction. These castings, also the elbow pieces where no valves are required, are to be of approved material other than ordinary cast iron. The length of pipe attached to the valve or elbow piece is to be of galvanised steel of standard steam pipe quality.

### Protection of Pipes and Valves

**D 2519** In all cargo spaces or coal bunkers scupper pipes, discharges and screw-down valves and their controls are to be well protected; in coal bunkers the protection is to be of steel.

## Section 3

## OIL FUEL AND CARGO OILS HAVING A FLASH POINT ABOVE 65,5° C.

### General

**301** In addition to the special requirements detailed in this Section, the requirements of E 2 relating to bilge and ballast are to be complied with in so far as they are applicable to the drainage of tanks, oil bilges and cofferdams.

**302** The flash point (closed test) of oil fuel for use in steam and motor ships classed for unrestricted service is in general not to be less than 65,5° C. For emergency generator engines a flash point of not less than 43° C. is permissible.

Fuels with flash points lower than 65,5° C. may be used in ships intended for service restricted to geographical limits where it can be ensured that the temperature of the machinery and boiler spaces will always be 16,5° C. below the flash point of the fuel. In such cases, safety precautions and the arrangements for storage and pumping will be specially considered. However, in no case is the flash point of the fuel to be less than 54° C. when supplied for oil fired boilers or less than 43° C. for oil engines.

When it is desired to carry a quantity of fuel having a flash point below 43° C. for special services, e.g. aviation spirit for use in helicopters, full particulars of the proposed arrangements are to be submitted for special consideration.

### Oil Fuel Pumps and Oil Burning Appliances

**303** In every ship where steam for the main propelling engines, or for auxiliary machinery which is required for essential services, is generated by burning oil fuel under pressure, there are to be not less than two oil burning units, each unit comprising a pressure pump, a suction filter, a discharge filter and a heater.

In two unit installations, each unit is to be capable of supplying fuel for generating all the steam required for essential services.

In installations of three or more units, the capacities and arrangements of the units are to be such that all the steam required for essential services can be maintained with any one unit out of action.

**304** Unit pressure pumps for the oil burning system are to be entirely separate from the feed, bilge or ballast systems.

**305** In systems where oil is fed to the burners by gravity, duplex filters are to be fitted in the supply pipe line to the burners and so arranged that one filter can be opened up when the other is in use.

**306** If oil fuel is sprayed by steam, means are to be provided to carry or make up the fresh water used for this purpose.

**307** A starting-up oil fuel unit, including an auxiliary heater and hand pump, or other suitable starting-up device, which does not require power from shore, is to be provided.

**308** All pumps used in connection with oil fuel are to be provided with effective escape valves which are to be in close circuit, i.e., discharging back to the suction side of the pumps.

Escape valves are also to be fitted on the oil side of the heaters, discharging to the pump suction line, to the tray under the unit, or to other approved position, and are to be adjusted to operate at a pressure of 3,5 kg. per cm.$^2$ above that of the pump escape valve.

**309** Where a power driven transfer pump is necessary for pumping up the settling tanks in motorships and steamships, a stand-by pump is to be provided and connected ready for use, or alternatively, emergency connections may be made to one of the unit pumps or to another suitable power driven pump.

### Oil Pipes and Fittings

**310** Pipes conveying heated oil under pressure are to be of seamless steel having flanged couplings and placed in sight above the platform in well lighted parts of the stokehold or engine room.

The flanges are to be machined and the jointing material, which is to be impervious to oil heated to 120° C., is to be the thinnest possible, so that the flanges are practically metal to metal. The scantlings of the pipes and their flanges are to be suitable for at least 14 kg. per cm.$^2$ working pressure, or the pressure to which the relief valves are adjusted, whichever is the greater.

The pipes, heaters and their fittings are to be tested after jointing to not less than 28 kg. per cm.$^2$, or twice the working pressure, whichever is the greater.

The thickness of the oil fuel pressure pipes is to be determined from the formula contained in E 512.

**311** The short joining lengths of pipes to the burners from the control valves on the boiler front may have cone unions of specially robust construction.

Flexible pipes of approved material and design may be used for the burner pipes provided spare lengths, complete with couplings, be carried on board.

A quick closing master valve is to be fitted on the hot oil supply to each boiler manifold.

**312** Transfer, suction and other low pressure oil pipes and all pipes passing through oil storage tanks are to be made of cast or wrought iron or steel, having flanged joints suitable for a working pressure of not less than 7 kg. per cm.$^2$ The flanges are to be machined and the jointing material is to be impervious to oil. Oil pipes within the engine and boiler spaces are to be fitted where they can be readily inspected and repaired, and after jointing they are to be tested to 3,5 kg. per cm.$^2$, or twice the maximum working pressure, whichever is the greater.

### Valves and Cocks

**313** The valves, cocks and their pipe connections are to be so arranged that oil cannot be admitted into tanks which are not structurally suitable for the carriage of oil or into tanks which can be used for the carriage of fresh water intended for boiler feed or for drinking.

In passenger ships provision is to be made for the transfer of oil fuel from any oil fuel storage or settling tank to any other oil fuel storage or settling tank in the event of fire or damage.

**314** Every oil fuel suction pipe from a double bottom tank is to be fitted with a valve or cock.

**315** Every oil fuel suction pipe from a storage, settling and daily service tank situated above the double bottom and every oil fuel levelling pipe within the boiler room or

engine room is to be fitted with a valve or cock secured to the tank. In the case of fore peak tanks, these valves are to be fitted on the tank side of the bulkhead.

In the engine and boiler spaces, such valves and cocks are to be capable of being closed locally and from positions which will always be accessible in the event of fire taking place in these spaces. Indicators are to be provided at the valves and cocks and at the remote control positions to show whether they are open or shut.

In the case of very small tanks consideration will be given to the omission of remote controls.

**316** Every oil fuel suction pipe which is led into the engine and boiler spaces from a tank situated above the double bottom outside these spaces is to be fitted in the machinery space with a remote controlled valve, except where the valve on the tank is already remote controlled.

**317** All valves and cocks forming part of the oil fuel installation are to be capable of being controlled from readily accessible positions which, in the engine and boiler spaces, are to be above the working platform.

Valves or cocks are to be interposed between the pumps and the suction and discharge pipes, in order that any pump may be shut off for opening up and overhauling.

Oil fuel valves are to be so constructed as to prevent the possibility of any cover being slacked back or loosened when operating the valves. The valves and cocks are to be fitted with legible nameplates.

**318** Where the filling pipes to deep oil tanks are not connected to the tanks near the top, they are to be provided with non-return valves at the tanks or with valves or cocks fitted and controlled as in the case of the outlet valves or cocks on these tanks.

**319** Open drains for removing the water from oil tanks are to be fitted with cocks or valves of self-closing type and suitable provision is to be made for collecting the oily discharge.

### Oil Fired Galleys

**320** The fuel oil tank is to be located outside the galley and is to be fitted with approved means of filling and venting. The fuel supply to the burners is to be controlled from a position which will always be accessible in the event of a fire occuring in the galley. The galley is to be well ventilated.

When liquefied petroleum gas is used similar provisions are to be made.

### Filling Arrangements

**321** In passenger ships, the filling station is to be isolated from other spaces and is to be efficiently drained and ventilated. Provision is to be made against over-pressure in the filling pipe lines and any relief valve fitted for this purpose is to discharge to an overflow tank or other safe position.

### Alternative Carriage of Oil Fuel and Water Ballast

**322** Where it is intended to carry oil fuel and water ballast in the same compartments alternatively, the valves or cocks connecting the suction pipes of these compartments with the ballast pump and those connecting them with the oil fuel transfer pump are to be so arranged that the oil may be pumped from any one compartment by the oil fuel pump at the same time as the ballast pump is being used on any other compartment.

Where settling or service tanks are fitted each having a capacity sufficient to permit of 12 hours' normal service without replenishment, the above requirement may be dispensed with.

**323** Attention is drawn to the statutory regulations issued by National Authorities in connection with the International Convention for Prevention of Pollution of the Sea by Oil, 1954.

### Deep Tanks for the Alternative Carriage of Oil, Water Ballast or Dry Cargo

**324** In the case of deep tanks which can be used for the carriage of oil fuel, cargo oil, water ballast or dry cargo, provision is to be made for blank flanging the oil and water ballast filling and suction pipes, also the steam heating coils if retained in place, when the tank is used for dry cargo and for blank flanging the bilge suction pipes when the tanks are used for oil or water ballast.

If the deep tanks are connected to an overflow system the arrangements are to be such that liquid or vapour from other tanks cannot enter the deep tanks when dry cargo is carried in them.

### Oily Bilge Drainage and Sediment Suctions

**325** Provision is to be made for the drainage of oil gutterways, oil wells and cofferdams. (*See* D 2024 to D 2028, quoted at end of this Section.)

### Fresh Water Piping

**326** Pipes in connection with compartments used for storing boiler feed water are to be separate and distinct from any pipes which may be used for oil or oily water, and are not to be led through tanks which contain oil, nor are oil pipes to be led through boiler feed water tanks.

Similar precautions are necessary when the connections are such that fresh water carried in other tanks can be used as reserve feed water.

### Service, Settling and other Oil Fuel Tanks

**327** In general, the minimum thickness of the plating of these tanks, when they do not form part of the structure of the ship, is to be 6 mm., but in the case of very small tanks, the minimum thickness may be 3 mm. Adequate stiffening of the plating is to be provided where necessary.

On completion the tanks are to be tested by a head of water equal to the maximum to which the tanks may be subjected but not less than 2,5 metres above the crown of the tank.

### Water Drainage from Settling Tanks

**328** Settling tanks are to be provided with means for draining water from the bottom of the tanks.

If settling tanks are not provided, the oil fuel bunkers or daily service tanks are to be fitted with water drains (*see* 319).

### Ventilation

**329** The spaces in which the oil fuel burning appliances, and the oil fuel settling and service tanks are fitted, are to be well ventilated and easy of access.

### Boiler Insulation and Air Circulation in Boiler Room

**330** The boilers are to be suitably lagged. The clearance spaces between the boilers and tops of the double bottom tanks and between the boilers and the sides of the storage tanks in which oil fuel or cargo oil is carried, are to be adequate for the free circulation of air necessary to keep the temperature of the stored oil well below its flash point.

**331** Where water tube boilers are installed, there should be a space of at least 760 mm. between the tank top and the underside of the pans forming the bottom of the combustion spaces.

**332** Smoke-box doors are to be shielded and well fitting, and the uptake joints made airtight.

### Funnel Dampers

**333** Dampers which are capable of completely closing the gas passages are not to be fitted to inner funnels of ships equipped for burning oil fuel only. In ships burning oil or coal alternatively, dampers may be retained if they are provided with a suitable device whereby they may be securely locked in the fully open position.

### Steam Heating Arrangements

**334** Where steam is used for heating oil fuel, cargo oil or lubricating oil, either in bunkers, tanks, heaters or separators, the exhaust drains are to discharge the condensate into an observation tank in a well lighted and accessible position where it can be readily seen whether or not it is free from oil (*see* E 1118).

**335** The steam heating pipes in contact with oil are to be of iron, steel, approved aluminium alloy or approved copper alloy and are to be tested, after being fitted on board, to twice the maximum pressure to which they can be subjected.

**336** The working pressure of steel steam heating pipes is to be determined from the formula in E 512.

### Control of Pumps

**337** The power supply to the oil fuel transfer and pressure pumps and to the cargo oil pumps is to be capable of being stopped from a position which will always be accessible in the event of fire taking place in the compartment in which they are situated, as well as from the compartment itself.

### Precautions against Fire

**338** Settling and daily service oil fuel tanks and oil fuel filters are not to be situated immediately above boilers or other highly heated surfaces.

**339** Oil fuel pressure pipes are to be led, wherever practicable, remote from heated surfaces and electrical appliances, but where this is impracticable, the pipes are to have a minimum number of joints and are to be led in well lighted and readily visible positions.

**340** Short sounding pipes to oil fuel tanks are not to be situated adjacent to boilers or to electric generators or motors. (For alternative sounding arrangements, *see* E 414.)

**341** Water service pipes and hoses are to be fitted in order that the floor plates and tank top or shell plating in way of boilers, oil fuel apparatus or deep storage tanks in the engine and boiler spaces can at any time be flushed with sea water.

**342** So far as is practicable the use of wood is to be avoided in the engine rooms, boiler rooms and tunnels of ships burning oil fuel.

**343** Drip trays are to be fitted at the furnace mouths to intercept oil escaping from the burners and under all other oil fuel appliances which require to be opened up frequently for cleaning or adjustment. The arrangements are to be such that a burner cannot be withdrawn unless the oil fuel supply to that burner is shut off.

For alternately fired furnaces of boilers using exhaust gases and oil fuel, the exhaust gas inlet pipe is to be provided with an isolating device and interlocking arrangements whereby oil fuel can only be supplied to the burners when the isolating device is closed to the boiler.

### Separation of Cargo Oils from Oil Fuel

**344** Pipes conveying vegetable oils or similar cargo oils are not to be led through oil fuel tanks, nor are oil fuel pipes to be led through tanks containing these cargo oils. (*See* D 2105, quoted at end of this Section.)

### Oil Drainage in way of Refrigerated Cargo Chambers

**345** The insulation of all oil storage tank tops is to have an air space of 50 mm. provided between the under side of the insulation and the tank top plating and the supporting battens are to be arranged to provide free drainage to the bilges. Alternatively, either 12,5 mm. thick inodorous material, or successive coatings of approved oil resisting compositions to a total thickness of about 5 mm. may be applied to the tank top plating.

**346** A cofferdam is to be fitted separating deep tanks intended for the carriage of oil from refrigerated compartments unless the tank bulkhead is wholly welded including its boundary connections, in which case the cofferdam may be omitted and an air space of not less than 50 mm. arranged between the insulation and the bulkhead plating to provide for free drainage from the latter into the oil gutterway and thence to the bilges.

Provision is to be made for ventilating the cofferdam or air space, the vents being led to the open air and their outlets being fitted with a wire gauze diaphragm which can easily be removed for renewal.

### Extracts from Chapter D for reference

#### Protection and Drainage

**D 2024** Compartments carrying oil are to be separated by cofferdams from those carrying fresh water; oil fuel compartments are to be similarly separated from those carrying vegetable oil. Cofferdams are to be suitably ventilated.

**D 2025** Sparring or lining is to be fitted on the bulkheads in holds to prevent leakage of oil coming into contact with the cargo. Gutterways are to be arranged at the foot of these bulkheads to ensure that leakage shall have free drainage to the wells or limbers. Gutterways are also to be fitted in boiler spaces.

**D 2026** Where a bulkhead, including its boundary connections, is wholly welded, the requirements of 2025 may be dispensed with, except that a gutterway is to be fitted in the boiler room.

**D 2027** Ceiling on the inner bottom, if fitted, is to be laid on battens not less than 12 mm. in thickness. Battens are to be so laid as to permit the drainage of oil to the bilges or wells.

**D 2028** Drip trays or gutterways, with suitable draining arrangements, are to be provided for all tanks which do not form part of the hull structure, at pumps, valves and elsewhere where there is a possibility of leakage. Drip trays are also to be fitted under oiltight decks, except if these are completely welded when the drip trays need only be fitted over the boilers.

**D 2029** If cargo or coal is carried in a compartment adjacent to an oil fuel settling tank which may be heated, the compartment side of the bulkhead or deck is to be insulated.

#### Vegetable and Similar Oils

**D 2105** Deep or peak tanks carrying vegetable or similar oils are to be separated from those carrying oil fuel or fresh water, by a cofferdam.

## Section 4

### AIR, OVERFLOW AND SOUNDING PIPES

#### Air and Overflow Pipes

**401** Air pipes are to be fitted at the opposite end of the tank to that at which the filling pipes are placed and/or at the highest part of the tank.

Where the tank top is of unusual or irregular profile special consideration will be given to the number and position of the air pipes.

Nameplates are to be affixed to the upper ends of all air pipes.

**402** Air pipes to double bottom tanks, deep tanks extending to the shell plating or tanks which can be run up from the sea are to be led to above the bulkhead deck.

Air pipes to oil fuel and cargo oil tanks, cofferdams and all tanks which can be pumped up are to be led to the open. (For height of air pipes above deck, *see* D 2409, quoted at end of this Section.)

**403** The open ends of air pipes to oil fuel and cargo oil tanks are to be situated where no danger will be incurred from issuing oil or vapour when the tank is being filled and each opening is to be furnished with a wire gauze diaphragm of incorrodible material which can be readily removed for cleaning or renewal.

**404** Air pipes from lubricating oil storage tanks may terminate in the machinery space, provided the open ends are so situated that issuing oil cannot come into contact with electrical equipment or heated surfaces.

**405** The closing appliances fitted to tank air pipes, in accordance with D 2410, are to be of a type which will prevent excessive pressure coming on the tanks.

Provision is to be made for relieving vacuum when the tanks are being pumped out and for this purpose a hole about 9,5 mm. in diameter in the bend of the air pipe or in a suitable position in the closing device will be acceptable.

**406** In the case of all tanks which can be pumped up, either by the ship's pumps or by shore pumps through a filling main, the total cross-sectional area of the air pipes to each tank or of the overflow pipes where an overflow system is provided, is to be not less than 25 per cent greater than the effective area of the respective filling pipes.

Where tanks are fitted with cross flooding connections the air pipes are to be of adequate area for these connections. Wood plugs and other devices which can be secured closed are not to be fitted at the outlets.

In wire gauze diaphragms at air pipe openings, the area of the clear opening is to be not less than the cross-sectional area required for the pipe.

Air pipes are to be not less than 50 mm. bore.

**407** The arrangement of the overflow system is to be such that in the event of any one of the tanks being bilged, tanks situated in other watertight compartments of the ship cannot be flooded from the sea through the overflow main.

Air and overflow pipes are to be arranged to be self-draining under normal conditions of trim.

**408** Overflow pipes are to be fitted to oil fuel storage, settling and daily service tanks when the pressure head corresponding to the height of the air pipe is greater than that for which the tanks are suitable or when the sectional area of the air pipe is less than required by 406.

The pipe is to be led to an overflow tank of adequate capacity or to a storage tank having a space reserved for overflow purposes.

A sight glass is to be provided in the overflow pipe to indicate when the tanks are overflowing or, alternatively, an alarm device is to be provided to give warning either when the tanks are overflowing or when the oil reaches a predetermined level in the tanks.

**409** Where overflows from tanks which are used for the alternative carriage of oil and water ballast are connected to an overflow system, arrangements are to be made to prevent water ballast overflowing into tanks containing oil (*see* also E 324).

**410** Air and overflow pipes are to be of steel or wrought iron having a minimum thickness of 5 mm. or other approved material and thickness. Steel or wrought iron pipes slightly less in thickness may be accepted, provided they be suitably coated to prevent corrosion. Where not in contact with oil fuel or cargo oil, suitable protection may be provided by galvanising the pipes on completion.

The portions of air and overflow pipes fitted above deck are to be of steel, wrought iron or other approved ductile material and of robust construction.

Where flanged connections are employed, heavy flanges with closely spaced bolts are to be fitted.

### Sounding Pipes

**411** Provision is to be made for sounding all tanks, and the bilges of those compartments which are not at all times readily accessible.

The soundings are to be taken as near the suction pipes as practicable.

**412** Sounding pipes, including those for the double bottom tanks below the machinery spaces, should be led to positions above the bulkhead deck which are at all times accessible.

These pipes should be as straight as practicable, and if curved to suit the structure of the ship, the curvature must be sufficiently easy to permit the ready passage of the sounding rod or chain.

Nameplates are to be affixed to the upper ends of all sounding pipes.

**413** In machinery spaces and tunnels where it is not always practicable to extend the sounding pipes as mentioned in 412, short sounding pipes extending to readily accessible positions above the platform may be fitted, provided those to oil fuel and lubricating oil tanks are not situated adjacent to boilers or electric generators or motors, and are fitted with cocks having parallel plugs with permanently attached handles so loaded that, on being released, they automatically close the cocks.

Short sounding pipes to tanks other than oil tanks are to be fitted with shut-off cocks or with screw caps attached to the pipes by chains.

In passenger ships, short sounding pipes are permissible only for sounding cofferdams and double bottom tanks situated in the machinery space and are in all cases to be fitted with self-closing cocks as described in the foregoing.

**414** Tank sounding devices of approved type may be used in lieu of sounding pipes. These devices are to be tested, after fitting on board, to the satisfaction of the Surveyors.

**415** If gauge glasses are used for indicating the level of liquid in tanks containing lubricating oil, oil fuel or other inflammable liquid, the glasses are to be of heat-resisting quality adequately protected from mechanical damage and fitted with self-closing valves at the lower ends and at the top ends if these are connected to the tanks below the maximum liquid level.

**416** Sounding pipes to oil compartments are not to terminate within refrigerated cargo chambers or in the fan and battery rooms for these chambers, nor are these pipes to terminate in enclosed spaces from which access is provided to refrigerated cargo chambers or their fan and battery rooms, if it be practicable to avoid doing so.

Where these sounding pipes do terminate in such spaces they are to be fitted with self-closing cocks having parallel plugs.

**417** Sounding pipes are to be not less than 32 mm. bore. All sounding pipes, whether for compartments or tanks, which pass through refrigerated spaces, or the insulation thereof, in which the temperatures contemplated are 0° C. or below, are to be not less than 65 mm. bore.

**418** All pipes, including scupper pipes, air pipes and sounding pipes which pass through chambers intended for the carriage or storage of refrigerated produce are to be well insulated.

Where such pipes pass through chambers intended for a temperature of 0° C. or below they are also to be insulated from the steel structure except in positions where the temperature of the structure is mainly controlled by the external temperature and will normally be above freezing point. Pipes passing through a deck plate within the ship side insulation, where the deck is fully insulated below and has an insulation ribband on top, are to be attached to the deck plating.

In the case of pipes adjacent to the shell plating, metallic contact between the pipes and the shell plating or frames is to be arranged as far as practicable.

The air refreshing pipes to and from refrigerated compartments need not, however, be insulated from the steel work.

**419** Sounding pipes are to be of steel or wrought iron having a minimum thickness of 4,5 mm. or other approved material and thickness. Steel or wrought iron pipes slightly less in thickness may be accepted, provided they be suitably coated to prevent corrosion. Where not in contact with oil fuel or cargo oil, suitable protection may be provided by galvanising the pipes on completion.

Where flanged connections are employed, heavy flanges with closely spaced bolts are to be fitted.

**420** Striking plates of adequate thickness and size are to be fitted under open ended sounding pipes.

When slotted sounding pipes having closed ends are employed, the closing plugs are to be of substantial construction.

**421** Elbow sounding pipes are not to be used for deep tanks unless the elbows and pipes are situated within closed cofferdams or within tanks containing similar liquids.

They may, however, be fitted to other tanks and may be used for sounding bilges, provided it is not practicable to lead them direct to the tanks or compartments.

The elbows are to be of heavy construction and adequately supported.

In passenger ships, elbow sounding pipes are not permissible.

**Extract from Chapter D for reference**

**Air and Sounding Pipes**

**D 2409** The height of air pipes, from upper surface of deck to opening, on decks exposed to the weather, is to be as follows :—

On the uppermost continuous deck where the draught is the maximum permitted for the dimensions of the ship, with the depth D measured to that deck ... 915 mm.

On raised quarter decks ... ... ... 760 mm.

On superstructure decks other than raised quarter decks, but including those extended for the full length of the ship ... ... ... ... ... ... 457 mm.

**D 2410** Openings of air and sounding pipes are to be provided with satisfactory arrangements to prevent the free entry of water.

**D 2411** Striking plates of sufficient thickness, or their equivalent, are to be fitted under all sounding pipes.

**D 2412** In all cargo spaces or coal bunkers, air and sounding pipes are to be well protected and in coal bunkers the protection is to be of steel.

## Section 5

### PRESSURE PIPES

**General**

**501** The requirements of this section are primarily intended for piping systems in which the operating pressure is 7 kg. per cm.$^2$ and over.

**Copper and Copper Alloy Pipes**

**502** Copper and copper alloy pipes are to be seamless or of approved welded type.

Branches are to be provided by cast or stamped fittings, by pipe pressings, or by other approved fabrications.

**503** Brazing and welding materials are to be suitable for the operating temperature. All brazing and welding is to be carried out to the satisfaction of the Surveyors.

**504** The maximum working temperatures permitted for pipe and branch materials are indicated in Table 1. Where it is proposed to use other copper alloys, particulars of chemical composition and mechanical properties at the working temperature including, if applicable, creep and rupture data, are to be submitted for consideration.

**505** Where copper and copper alloy pipes are bent, they are to be made 10 per cent thicker than required by 506 to provide for thinning at the bend.

In no case is the radius of curvature at the centre line of the pipe to be less than twice the external diameter of the pipe.

**506** The minimum thickness of seamless copper and copper alloy pipes is to be determined by the following formula:—

$$t = \frac{WP \times D}{2f} + C \qquad \text{or} \qquad WP = \frac{2f\,(t - C)}{D}$$

where $t$ = thickness in millimetres,

$WP$ = working pressure in kg. per cm.$^2$, which in the case of feed pipes, is to be 1,25 times the boiler pressure,

$D$ = external diameter in millimetres,

$f$ = nominal stress, in kg. per cm.$^2$, from Table 1. Intermediate values of stresses to be obtained by linear interpolation,

$C = 0{,}8$.

**507** Pipes which have been hardened by cold bending are to be suitably heat treated on completion of fabrication and prior to testing by hydraulic pressure. Copper pipes are to be annealed and copper alloy pipes are to be either annealed or stress relief heat treated.

**Steel Pipes**

**508** Steel pipes are to comply with the material requirements of P9. For alloy steels particulars of chemical composition, deoxidising medium and operating temperature are to be submitted for approval. Similar particulars are also to be submitted for carbon steel where the proposed operating temperature exceeds 399° C. The temperature limitations indicated in Table 2 are maxima for the types of steel listed but are not necessarily acceptable for all steels of these types.

**509** Pipes of seamless or other approved type are to be used for feed pipes, for pressure pipes conveying heated oil and for other pressure pipes where the working pressure exceeds 17,5 kg. per cm.$^2$ or the temperature exceeds 218° C.

**510** Pipes other than those mentioned in 509 may be lap welded provided they are made by an approved mechanical process.

TABLE 1

| PIPE MATERIAL | Minimum tensile strength Kg. per mm.² | 0,5 per cent proof stress Kg. per mm.² | NOMINAL STRESS IN KG. PER CM.² AT THE FOLLOWING METAL TEMPERATURES IN °C. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Up to 65,5 | 93 | 121 | 149 | 177 | 204 | 232 | 260 | 288 |
| Copper ... | 22 | 6,3 | 422 | 408 | 394 | 337 | 267 | 211 | | | |
| Aluminium Brass ... | 33 | 12,6 | 703 | 689 | 668 | 647 | 422 | 211 | | | |
| Copper Nickel 99/5 & 90/10 | 28,5 | 14,2 | 703 | 689 | 668 | 647 | 605 | 562 | 492 | 422 | |
| Copper Nickel 70/30 ... | 39,5 | 14,2 | 844 | 787 | 745 | 703 | 675 | 647 | 619 | 591 | 562 |

**511** Pipes having forge butt welded longitudinal seams are not to be used for oil fuel systems, for heating coils in oil tanks, or for pressures exceeding 3,5 kg. per cm.²

**512** The thickness of steel pipes intended for steam, feed, air, oil fuel and other pressure services is to be determined by the following formula and the thickness so obtained is suitable for straight pipes and pipes which are to be bent.

The formula does not provide for adverse corrosion conditions and steam and feed pipes over 25 mm. bore intended for use with low pressure boilers (up to 17,5 kg. per cm.² working pressure) and any boilers with open feed systems are to be made one gauge (about 0,5 mm.) thicker than required by the formula.

The formula also makes provision for a manufacturing tolerance of —15 per cent and where tubes are specified to a closer negative tolerance than this figure, the rule thickness may, if desired, be reduced to suit the specified tolerance.

Seamless pipes for all pressures and temperatures:

$$t = \left(\frac{WP \times D}{2f} + 1{,}25\right) 1{,}275$$

(For lap welded pipes for pressures up to 17,5 kg. per cm.² and temperatures up to 218° C. the thickness is to be 50 per cent greater than required for seamless pipes.)

Where t = thickness of pipe, in millimetres,

WP = working pressure, in kg. per cm.²

For feed pipes, WP is to be taken as 1,25 times the boiler pressure, or the maximum pressure which can be developed in the feed line in normal service, whichever is the greater.

With water tube boiler installations, WP is to be taken as the approved boiler pressure for steam pipes between the boiler and integral superheater and as the pressure to which the superheater safety valves are set for the steam pipes leading from the superheater. Where the superheater safety valves are controlled by pilot valves operated from the saturated steam drum then WP for the steam pipes leading from the superheater is to be taken as the boiler pressure.

NOTE.—In installations where the boiler pressure, as controlled by the safety valve settings, is less than the approved boiler pressure it will be permissible for thicknesses of external steam and feed pipes to be based on the former.

D= outside diameter of pipe, in millimetres.

$f$ = nominal stress in kg. per cm.² with the following values:—

*For temperatures up to and including* 343° C.

$f$ is to be taken as $\frac{1}{5}$ of the specified minimum tensile strength of the pipe material. Values of $f$ are given in the first column of Table 2 for representative carbon steels and may be obtained on the foregoing basis for any other carbon or low alloy pipe steel approved for pressure service.

*For temperatures above* 343° C.

$f$ is to be taken from Table 2 which gives values of $f$ for a limited number of pipe steels of approved composition in common use for superheated steam pipe service. Values of $f$ for other steels will receive special consideration.

Steam temperature is to be taken as the designed operating temperature for the pipe line provided the temperature at the superheater outlet is closely controlled. Where temperature fluctuations exceeding 14° C. above the

TABLE 2

| PIPE STEEL | Minimum tensile strength kg. per mm². | STEAM PIPES—NOMINAL STRESS IN KG. PER CM² AT FOLLOWING STEAM TEMPERATURES IN °C. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 343 | 371 | 399 | 427 | 454 | 482 | 510 | 538 | 566 |
| Carbon ... ... ... | 36 | 720 | 690 | 650 | 590 | 535 | 350 | | | |
| | 42,5 | 850 | 810 | 760 | 655 | 535 | 350 | | | |
| ½% Mo. ... ... ... | 39,5 | 790 | 790 | 790 | 770 | 760 | * | | | |
| | 44 | 880 | 880 | 880 | 870 | 850 | * | | | |
| ½% Cr., ½% Mo. ... ... | 39,5 | 790 | 790 | 790 | 770 | 760 | 730 | 530 | | |
| | 44 | 880 | 880 | 880 | 870 | 850 | 770 | 530 | | |
| 1% Cr., ½% Mo. ... ... | 42,5 | 850 | 850 | 850 | 850 | 845 | 810 | 550 | 340 | |
| 2¼% Cr., 1% Mo. ... ... | 42,5 | 850 | 850 | 850 | 850 | 845 | 810 | 590 | 420 | 325 |
| ½% Mo., ¼% V. ... ... | 49 | 980 | 980 | 980 | 980 | 980 | 970 | 770 | 490 | 365 |

* ½% Mo. material is not recommended for higher temperatures than 454° C. because of its poor rupture ductility.

designed temperature are to be expected in normal service the steam temperature for use with the Table is to be increased by the amount of this excess.

For intermediate temperatures, values of $f$ may be obtained by interpolation.

Where it is proposed to use, for high temperature service, alloy steels other than those stated in the Table, particulars of tube sizes, working conditions and appropriate British or other national standard material specification giving the data required by 508 are to be submitted for consideration.

Where the material does not conform to an established standard, particulars of chemical composition, deoxidising medium, heat treatment, mechanical properties and measured or estimated long-term creep and rupture data at the proposed operating temperature are to be submitted for the purpose of assessing a safe working stress.

### Pipe Joints

**513** Joints in pressure pipe lines may be made by bolted flanges or by butt welds between pipes or between pipes and valve chests, or other fittings, but with the latter system it is desirable that a few flanged joints be provided at suitable positions to facilitate installation, cold "pull up" and inspection at periodical surveys.

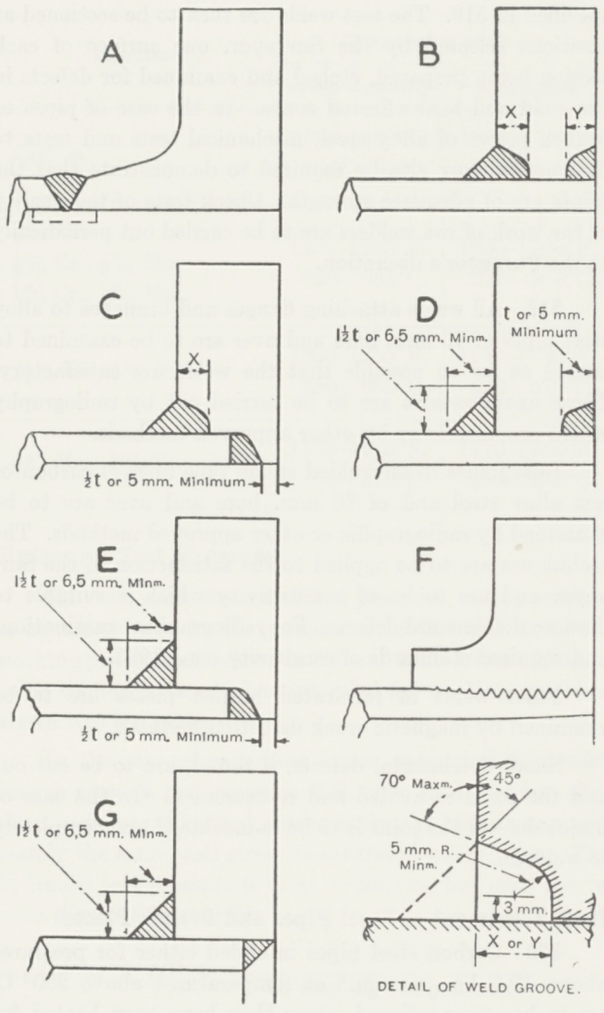
Where pressure pipe lines are assembled and butt welded in place the piping is to be arranged well clear of adjacent structures to permit sufficient access for preheating, welding, heat treatment and examination of the joints.

In main steam pipe lines with butt welded joints, inspection bosses with screwed plugs or equivalent are to be provided in the pipe line and adjacent to the joints for the entry of introscopes or other optical devices unless other approved means for internal examination are made. If plugs are seal welded both plug and boss should be of mild steel. For the purpose of periodical surveys the locations of butt welded joints are to be clearly marked and lagging in way of these joints and inspection bosses should be portable; for hydraulic testing of the pipe lines the terminal valves should be capable of withstanding, when closed, a test pressure of twice the working pressure. In the supporting and securing arrangements for the pipe line, provision is to be made for these hydraulic test conditions.

### Steel Pipe Flanges

**514** Flanges are to be weldless and of material suitable for the working temperature. They may be attached to pipes by screwing and expanding or by welding. Acceptable methods of attachment are illustrated and Table 4 indicates the pressures and temperatures for which the various types are acceptable.

ACCEPTABLE METHODS OF ATTACHING FLANGES TO STEEL PIPES




If backing rings are used with flange type A they are to fit closely to the bore of the pipe and should be removed after welding. The rings are to be made of the same material as the pipes or of good quality mild steel having a sulphur content not greater than 0,06 per cent. Flange types C and E are unsuitable for pipes under 76 millimetres bore.

Alternative methods of flange attachment and other types of pipe joints may be accepted provided details are submitted for special consideration.

For flange types B and C, dimension X is to be taken as t for carbon steel and 1½t for alloy steel pipes but is to be not less than shown in Table 3.

For flange type B, dimension Y is to be taken as t for carbon steel and 1½t for alloy steel pipes but is to be not less than 5 mm.

t is to be taken as the rule thickness of the pipe.

TABLE 3

| Pipe Bore | Dimension X Minimum |
|---|---|
| 13 mm. and 19 mm. | 6,5 mm. |
| 25 mm. to 38 mm. | 8,0 mm. |
| 50 mm. and over | 9,5 mm. |

TABLE 4

| Type of Flange Attachment | Service and Rating | | | |
|---|---|---|---|---|
| | Feed, Air, Oil Fuel and other fluids | | Steam | |
| | Pressure kg. per cm.² | Temperature °C. | Pressure kg. per cm.² | Temperature °C. |
| A | All Conditions | | All Conditions | |
| B & C | All Conditions | | 52,5 | 454 |
| D & E | 52,5 | 260 | 38,5 | 399 |
| F | 42 | | 31,5 | |
| G | 17,5 | | 17,5 | 260 |

**515** Where flanges are attached by screwing, the pipe and flange are to be screwed with a vanishing thread and the diameter of the screwed portion of the pipe over the thread must not be appreciably less than the outside diameter of the unscrewed pipe. After the flange has been screwed hard home the pipe is to be expanded into the flange.

The vanishing thread on a pipe is to be not less than three pitches in length, and the diameter at the root of the thread is to increase uniformly from the standard

root diameter to the diameter at the top of the thread. This may be produced by suitably grinding the dies, and the flange should be tapered out to the same formation.

### Welded Flanges, Pipe Joints and Branch Pieces

**516** Welding may be carried out by means of the shielded metal arc, inert gas metal arc, oxy-acetylene or other approved process.

In general, oxy-acetylene welding is suitable only for flange type A and is not to be applied to pipes exceeding 100 mm. diameter or 9,5 mm. thick.

When flanges are attached by welding or pipe-to-pipe joints are butt welded using the oxy-acetylene or metal arc process the filler rods, electrodes and fusible root inserts used are to be suitable for the materials of the parts to be joined.

All welding work is to be carried out in shop or ship in positions free from draughts or rapid changes of temperature.

Preheating under temperature control is to be employed when necessitated by the dimensions and composition of the materials to be welded and is to be effected by a method which ensures uniformity of temperature at the joint. The method of heating and the means adopted for temperature control are to be to the satisfaction of the Surveyors.

Where butt welds are employed in the attachment of flange type A, in pipe-to-pipe joints or in the construction of branch pieces, the adjacent pieces are to be matched at the bores. This may be effected by drifting, roller expanding, or machining provided the pipe wall is not reduced below the designed thickness. If the parts to be joined differ in wall thickness, the thicker wall is to be gradually tapered to that of the thinner at the butt joint. The welding necks of valve chests are to be sufficiently long to ensure that the valves are not distorted as the result of welding and subsequent heat treatment of the joints.

Butt welds may be reinforced externally by additional runs of weld metal. All welds in high pressure and high temperature pipe lines are to have a smooth surface and even contour; if necessary they are to be made smooth by grinding. No undercutting of the pipe at the edges of the weld is acceptable.

**517** Branches may be attached to pressure pipes by means of welding provided the pipe is reinforced at the branch by a compensating plate or collar or other approved means, or alternatively the thicknesses of pipe and branch are to be increased to maintain the strength of the pipe.

These requirements also apply to fabricated branch pieces.

**518** The welding procedure proposed for the attachment of flanges, valve chests and other fittings to pipes, pipes-to-pipes and the fabrication of branch pieces, whether in carbon or alloy steel, is to be approved by the Surveyors in the first instance before work is commenced. For this purpose representative specimens of such parts will be required for examination and test.

The assembly for the weld procedure test and the welding technique should simulate the conditions under which the work is to be done on the installation. Test welds are to be examined for defects by the appropriate method specified in 519. The test welds are then to be sectioned at positions selected by the Surveyor, one surface of each section being prepared, etched and examined for defects in the weld and heat affected zones. In the case of pipes or branch pieces of alloy steel, mechanical tests and tests to destruction may also be required to demonstrate that the joints are of adequate strength. Check tests of the quality of the work of the welders are to be carried out periodically at the Surveyor's discretion.

**519** All welds attaching flanges and branches to alloy steel pipes of 76 mm. bore and over are to be examined to ensure as far as possible that the welds are satisfactory. These examinations are to be carried out by radiography where practicable or by other approved methods.

Butt joints in all welded steam pipe lines of carbon or low alloy steel and of 76 mm. bore and over are to be examined by radiographic or other approved methods. The techniques are to be applied to the satisfaction of the Surveyor and are to be of a sensitivity which is suitable to disclose detrimental defects. For radiographic examinations and required standards of sensitivity *see* J 1923.

Fillet welds in fabricated branch pieces are to be examined by magnetic crack detection methods.

Small detrimental defects, if found, are to be cut out and the seam re-welded and re-examined. In the case of major defects the joint is to be re-machined and completely re-welded.

### Heat Treatment of Steel Pipes and Branch Pieces

**520** Carbon steel pipes intended either for pressures above 10,5 kg. per cm.$^2$ or temperatures above 260° C. are to be stress relieved where they have been heated for bending the pipe or for any other purpose and where the flanges have been attached by metal arc welding. Where oxy-acetylene welding has been employed, the pipes are to be normalised.

All alloy steel pipes and fabricated branch pieces are to be carefully and suitably heat treated under accurate temperature control after cold or hot bending, welding or

other hot work. Stress relieving or normalising may be used after metal arc welding, and normalising is required after bending and oxy-acetylene welding. Other methods of heat treatment will be considered on submission of full details.

Suitable temperatures for heat treatment are given in Table 5 and should be maintained for one hour per 25 mm. of wall thickness.

TABLE 5

| Pipe steel | Temperature limits for | |
|---|---|---|
| | Stress Relieving | Normalising |
| Carbon | 1110–1200°F.<br>600– 650°C. | 1700–1760°F.<br>927– 960°C. |
| ½% Mo.<br>½% Cr., ½% Mo.<br>1% Cr., ½% Mo. | 1150–1225°F.<br>620– 663°C. | 1700–1760°F.<br>927– 960°C. |
| 2¼% Cr., 1% Mo. | 1200–1255°F.<br>650– 680°C. | 1740–1780°F.<br>950– 970°C. |
| ½% Mo., ¼% V. | 1185–1240°F.<br>640– 670°C. | 1740–1780°F.<br>950– 970°C. |

### Hydraulic Test Pressures

**521** All main steam and feed pipes are, on completion, to be tested by hydraulic pressure to not less than twice the working pressure as defined in 506 and 512. Other pipes are to be similarly tested when intended for working pressures above 10,5 kg. per cm.$^2$

In the case of superheat steam pipes and fabricated branch pieces a test pressure (TP) is to be applied so that these parts are subjected, under hydraulic test, to approximately the same wall stress as saturated steam pipes. The hydraulic test pressure is to be as follows, but need not be more than 316 kg. per cm.$^2$

$$TP = 2\ WP \times \frac{f \text{ at } 343^\circ \text{ C.}}{f \text{ at working temperature}}$$

Where $f$ is obtained from Table 2.

If the individual pipes are assembled and the joints butt welded in place, an additional hydraulic test of 2WP is to be applied to the erected pipe line.

For the testing of the completed oil fuel pipes and heating coil systems after fitting on board *see* E 310, E 312 and E 335.

### Cast Iron Heating Pipes

**522** Where it is desired to use pressure pipes of cast iron, details are to be submitted.

## Section 6

### STEAM PIPE RANGES

### Provision for Expansion

**601** In all steam pipe ranges provision is to be made for expansion and contraction to take place without unduly straining the pipes.

Where corrugated pipes are used, particulars are to be submitted.

### Drainage

**602** The slope of the pipes and the number and position of the drain cocks or valves are to be such that water can be efficiently drained from any portion of the steam pipe range when the ship is in normal trim and is either upright or has a list up to 5 degrees.

Arrangements are to be made for ready access to the drain cocks or valves.

### Pipes in way of holds

**603** In general, steam pipes are not to be led through spaces which may be used for cargo, but where it is impracticable to avoid this arrangement, plans are to be submitted for consideration. The pipes are to be efficiently secured and insulated and well protected from mechanical damage. Pipe joints are to be as few as practicable and preferably butt welded. After fitting in place, the pipes are to be tested by hydraulic pressure to twice the working pressure.

If these pipes are led through shaft tunnels, pipe tunnels in way of cargo holds or through duct keels, they are to be efficiently secured and insulated.

### Reduced Pressure Lines

**604** Pipe lines which are situated on the low pressure side of reducing valves and which are not designed to withstand the full pressure at the source of supply are to be fitted with pressure gauges and with relief valves having sufficient discharge capacity to protect the piping against excessive pressure.

### Valves and Fittings

**605** Valves and fittings intended either for steam pressures above 10,5 kg. per cm.$^2$ or temperatures above 218° C. are to be of steel, carbon or low alloy, or other approved material suitable for the working temperature.

root diameter to the diameter at the top of the thread. This may be produced by suitably grinding the dies, and the flange should be tapered out to the same formation.

### Welded Flanges, Pipe Joints and Branch Pieces

**516** Welding may be carried out by means of the shielded metal arc, inert gas metal arc, oxy-acetylene or other approved process.

In general, oxy-acetylene welding is suitable only for flange type A and is not to be applied to pipes exceeding 100 mm. diameter or 9,5 mm. thick.

When flanges are attached by welding or pipe-to-pipe joints are butt welded using the oxy-acetylene or metal arc process the filler rods, electrodes and fusible root inserts used are to be suitable for the materials of the parts to be joined.

All welding work is to be carried out in shop or ship in positions free from draughts or rapid changes of temperature.

Preheating under temperature control is to be employed when necessitated by the dimensions and composition of the materials to be welded and is to be effected by a method which ensures uniformity of temperature at the joint. The method of heating and the means adopted for temperature control are to be to the satisfaction of the Surveyors.

Where butt welds are employed in the attachment of flange type A, in pipe-to-pipe joints or in the construction of branch pieces, the adjacent pieces are to be matched at the bores. This may be effected by drifting, roller expanding, or machining provided the pipe wall is not reduced below the designed thickness. If the parts to be joined differ in wall thickness, the thicker wall is to be gradually tapered to that of the thinner at the butt joint. The welding necks of valve chests are to be sufficiently long to ensure that the valves are not distorted as the result of welding and subsequent heat treatment of the joints.

Butt welds may be reinforced externally by additional runs of weld metal. All welds in high pressure and high temperature pipe lines are to have a smooth surface and even contour; if necessary they are to be made smooth by grinding. No undercutting of the pipe at the edges of the weld is acceptable.

**517** Branches may be attached to pressure pipes by means of welding provided the pipe is reinforced at the branch by a compensating plate or collar or other approved means, or alternatively the thicknesses of pipe and branch are to be increased to maintain the strength of the pipe.

These requirements also apply to fabricated branch pieces.

**518** The welding procedure proposed for the attachment of flanges, valve chests and other fittings to pipes, pipes-to-pipes and the fabrication of branch pieces, whether in carbon or alloy steel, is to be approved by the Surveyors in the first instance before work is commenced. For this purpose representative specimens of such parts will be required for examination and test.

The assembly for the weld procedure test and the welding technique should simulate the conditions under which the work is to be done on the installation. Test welds are to be examined for defects by the appropriate method specified in 519. The test welds are then to be sectioned at positions selected by the Surveyor, one surface of each section being prepared, etched and examined for defects in the weld and heat affected zones. In the case of pipes or branch pieces of alloy steel, mechanical tests and tests to destruction may also be required to demonstrate that the joints are of adequate strength. Check tests of the quality of the work of the welders are to be carried out periodically at the Surveyor's discretion.

**519** All welds attaching flanges and branches to alloy steel pipes of 76 mm. bore and over are to be examined to ensure as far as possible that the welds are satisfactory. These examinations are to be carried out by radiography where practicable or by other approved methods.

Butt joints in all welded steam pipe lines of carbon or low alloy steel and of 76 mm. bore and over are to be examined by radiographic or other approved methods. The techniques are to be applied to the satisfaction of the Surveyor and are to be of a sensitivity which is suitable to disclose detrimental defects. For radiographic examinations and required standards of sensitivity *see* J 1923.

Fillet welds in fabricated branch pieces are to be examined by magnetic crack detection methods.

Small detrimental defects, if found, are to be cut out and the seam re-welded and re-examined. In the case of major defects the joint is to be re-machined and completely re-welded.

### Heat Treatment of Steel Pipes and Branch Pieces

**520** Carbon steel pipes intended either for pressures above 10,5 kg. per cm.$^2$ or temperatures above 260° C. are to be stress relieved where they have been heated for bending the pipe or for any other purpose and where the flanges have been attached by metal arc welding. Where oxy-acetylene welding has been employed, the pipes are to be normalised.

All alloy steel pipes and fabricated branch pieces are to be carefully and suitably heat treated under accurate temperature control after cold or hot bending, welding or

other hot work. Stress relieving or normalising may be used after metal arc welding, and normalising is required after bending and oxy-acetylene welding. Other methods of heat treatment will be considered on submission of full details.

Suitable temperatures for heat treatment are given in Table 5 and should be maintained for one hour per 25 mm. of wall thickness.

TABLE 5

| Pipe steel | Temperature limits for | |
|---|---|---|
| | Stress Relieving | Normalising |
| Carbon | 1110–1200°F.<br>600– 650°C. | 1700–1760°F.<br>927– 960°C. |
| ½% Mo.<br>½% Cr., ½% Mo.<br>1% Cr., ½% Mo. | 1150–1225°F.<br>620– 663°C. | 1700–1760°F.<br>927– 960°C. |
| 2¼% Cr., 1% Mo. | 1200–1255°F.<br>650– 680°C. | 1740–1780°F.<br>950– 970°C. |
| ½% Mo., ¼% V. | 1185–1240°F.<br>640– 670°C. | 1740–1780°F.<br>950– 970°C. |

### Hydraulic Test Pressures

**521** All main steam and feed pipes are, on completion, to be tested by hydraulic pressure to not less than twice the working pressure as defined in 506 and 512. Other pipes are to be similarly tested when intended for working pressures above 10,5 kg. per cm.$^2$

In the case of superheat steam pipes and fabricated branch pieces a test pressure (TP) is to be applied so that these parts are subjected, under hydraulic test, to approximately the same wall stress as saturated steam pipes. The hydraulic test pressure is to be as follows, but need not be more than 316 kg. per cm.$^2$

$$TP = 2\ WP \times \frac{f \text{ at } 343^\circ \text{ C.}}{f \text{ at working temperature}}$$

Where $f$ is obtained from Table 2.

If the individual pipes are assembled and the joints butt welded in place, an additional hydraulic test of 2WP is to be applied to the erected pipe line.

For the testing of the completed oil fuel pipes and heating coil systems after fitting on board *see* E 310, E 312 and E 335.

### Cast Iron Heating Pipes

**522** Where it is desired to use pressure pipes of cast iron, details are to be submitted.

## Section 6

## STEAM PIPE RANGES

### Provision for Expansion

**601** In all steam pipe ranges provision is to be made for expansion and contraction to take place without unduly straining the pipes.

Where corrugated pipes are used, particulars are to be submitted.

### Drainage

**602** The slope of the pipes and the number and position of the drain cocks or valves are to be such that water can be efficiently drained from any portion of the steam pipe range when the ship is in normal trim and is either upright or has a list up to 5 degrees.

Arrangements are to be made for ready access to the drain cocks or valves.

### Pipes in way of holds

**603** In general, steam pipes are not to be led through spaces which may be used for cargo, but where it is impracticable to avoid this arrangement, plans are to be submitted for consideration. The pipes are to be efficiently secured and insulated and well protected from mechanical damage. Pipe joints are to be as few as practicable and preferably butt welded. After fitting in place, the pipes are to be tested by hydraulic pressure to twice the working pressure.

If these pipes are led through shaft tunnels, pipe tunnels in way of cargo holds or through duct keels, they are to be efficiently secured and insulated.

### Reduced Pressure Lines

**604** Pipe lines which are situated on the low pressure side of reducing valves and which are not designed to withstand the full pressure at the source of supply are to be fitted with pressure gauges and with relief valves having sufficient discharge capacity to protect the piping against excessive pressure.

### Valves and Fittings

**605** Valves and fittings intended either for steam pressures above 10,5 kg. per cm.$^2$ or temperatures above 218° C. are to be of steel, carbon or low alloy, or other approved material suitable for the working temperature.

Castings of bronze, iron and carbon steel may be used within the following limits of temperature and pressure:—

| | |
|---|---|
| Bronze | 218° C. 10,5 kg. per cm.$^2$ |
| Iron | 232° C. 10,5 kg. per cm.$^2$ |
| Carbon Steel | 454° C. all pressures. |

### Hydraulic Test Pressure

**606** All main steam and feed valves and fittings are to be tested by hydraulic pressure to not less than twice the working pressure as defined in E 506 and E 512. Other valves and fittings are to be similarly tested when intended for working pressures above 10,5 kg. per cm$^2$.

For the testing of boiler mountings *see* J 302 and J 1510.

### Steam for Fire Extinguishing in Cargo Holds

**607** Where steam is used for fire extinguishing in cargo holds, provision is to be made to prevent damage to cargo by leakage of steam or by drip.

Details of the proposed precautionary measures are to be submitted.

## Section 7

## BOILER FEED WATER SYSTEMS

### Feed Pumps

**701** Two separate means of feed are to be provided for all main, auxiliary and donkey boilers which are required for essential services, with the exception of boilers in which steam is generated exclusively by exhaust gases or steam, where one means of feed will be accepted provided an alternative steam supply is available.

**702** Two or more feed pumps are to be provided of sufficient capacity to supply the boilers under full load conditions with any one pump out of action.

**703** Feed pumps may be worked from the main engines or may be independently driven but at least one of the pumps required in 702 is to be independently driven.

**704** In twin screw ships in which there is only one independent feed pump each main engine is to be fitted with a feed pump. Where all the feed pumps are independently driven, the pumps are to be connected to deal with the condensate from both engines or from either engine.

**705** Independent feed pumps required for feeding the main boilers are to be fitted with automatic regulators for controlling their output.

**706** Where main-engine driven feed pumps are fitted and there is only one independent feed pump, a harbour feed pump or an injector is to be fitted to provide the second means of feed to the boilers which are in use when the main engines are not working.

**707** Feed pumps are to be provided with valves or cocks interposed between the pumps and the suction and the discharge pipes so that any pump may be opened up for overhaul while the others continue in operation.

### Sea Suction

**708** One of the independent feed pumps is to be provided with an emergency suction to the sea, except in the cases mentioned in 709.

Suctions are also to be provided from this pump to the hotwell or condenser, unless suitable stand-by connections have already been provided for this purpose.

**709** The sea suction to a feed pump may be omitted if large reserve feed tanks are provided and an evaporator of adequate capacity is fitted.

### Reserve Feed Water

**710** All ships fitted with boilers are to be provided with storage space for reserve feed water, the structural and piping arrangements being such that this water cannot be contaminated by oil or oily water.

### General Service Pump

**711** An auxiliary independent feed pump may be used for general service, provided it is not connected to tanks containing oil fuel or cargo oil or to tanks, cofferdams and bilges containing oily water.

The valves on the suction pipes from the hotwell or condenser and the feed drain tank or filter are to be of non-return type.

### Filters

**712** Where superheated steam is used in main or auxiliary engines of reciprocating type, filters are to be fitted to provide for the continuous filtration of the boiler feed water.

**713** Where a direct contact heater is supplied with exhaust steam from engines of reciprocating type, the feed water from the heater is to be led through the filters required by 712 or through additional filters arranged to provide for continuous filtration.

### Cross-references

**714** For materials, working pressure and test pressure of feed pipes, *see* E 501 to E 521.

For feed water level regulators for water tube boilers, *see* J 1708.

## Section 8

## ENGINE COOLING WATER SYSTEMS

### Main Supply

**801** Provision is to be made for an adequate supply of cooling water to the main propelling machinery and essential auxiliary engines, also to the lubricating oil and fresh water coolers and air coolers for electric propelling machinery where these coolers are fitted. The cooling water pump(s) may be worked from the engines or be driven independently.

### Alternative Supply

**802** Provision is also to be made for a separate emergency supply of cooling water from a suitable pump.

When selecting a pump for this purpose, consideration is to be given to the maximum pressure which it can develop if the overboard discharge valve is partly or fully closed and, when necessary, condenser doors, water boxes, etc., are to be protected by an approved device against inadvertent over-pressure. *See* H 445 for the hydraulic test pressure which condensers are required to withstand.

### Sea Inlets

**803** Not less than two sea inlets are to be provided for the pumps supplying the salt water cooling system, one for the main pump and one for the stand-by pump. Alternatively, the sea inlets may be connected to a suction line available to main and stand-by pumps.

These inlets are to be low inlets and one of them may be the ballast pump or general service pump sea inlet.

### Stand-by Fresh Water Pump

**804** Where fresh water cooling is employed, a stand-by fresh water pump need not be fitted if there be suitable emergency connections from a salt water system.

### Cooling Water Supply to Auxiliaries

**805** Where each auxiliary is fitted with a cooling water pump, stand-by means of cooling need not be provided. Where, however, a group of auxiliaries is supplied with cooling water from a common system, a stand-by cooling water pump is to be provided for this system. This pump may be a suitable general service pump.

The auxiliary cooling water pumps are to be connected to not less than two sea inlets, preferably one on each side of the ship.

### Strainers

**806** Where sea water is used for the direct cooling of the main engines and essential auxiliary engines, the cooling water suction pipes are to be provided with strainers which can be cleaned without interruption to the cooling water supply.

### Relief Valves

**807** Cooling water pumps worked from the main engines are to be provided with relief valves on the pump discharge.

### Copper and Copper Alloy Piping Systems

**808** When non-ferrous pipes are proposed for fresh and sea water piping systems, details of the materials and the duty for which they are intended may be submitted to the Society for approval.

In the selection of components for sea water piping systems, care should be taken to avoid metal combinations which may lead to galvanic corrosion in service.

*See* Chapter R(D) for Guidance Notes on Metal Pipes for Water Services.

## Section 9

## LUBRICATING OIL SYSTEMS

### Pumps

**901** In ships of unrestricted class in which the lubricating oil for the main engines (steam engines, oil engines, turbines or electric propelling motors), is circulated under pressure, a stand-by lubricating oil pump is to be provided where the following conditions apply:—

(a) The lubricating oil pump is independently driven and the total output of the main engines exceeds 500 b.h.p.

(b) One main engine with a built-in lubricating oil pump is fitted and the output of the engine exceeds 500 b.h.p.

(c) Two or more main engines each with a built in lubricating oil pump are fitted and the output of each engine exceeds 500 b.h.p.

The stand-by pump is to be of sufficient capacity to maintain the supply of oil for normal conditions with any one pump out of action. The pump is to be fitted and connected ready for immediate use but where this is not convenient in the case of high speed oil engines with built-in pumps, a complete spare pump may be accepted for installation of type (c).

Similar provision is to be made where separate lubricating oil systems are employed for piston cooling, the operation of reverse reduction gears, oil operated couplings and controllable pitch propellers, unless approved alternative arrangements are provided.

### Alarms

**902** An alarm device is to be provided and arranged to give audible warning in the event of the failure of, or an appreciable reduction in, the supply of lubricating oil from the pump.

### Emergency Supply for Main Turbines and Main Turbo-Generators

**903** A suitable emergency supply of lubricating oil is to be provided. This may be effected by arranging for an automatic gravity supply of lubricating oil sufficient to maintain adequate lubrication for not less than 3 minutes, and in the case of turbo-generators until the unloaded turbine comes to rest from its maximum rated running speed.

### Strainers

**904** Where the lubricating oil for the main propelling engines and for the generator engines in electrically propelled ships is circulated under pressure, provision is to be made for efficiently straining the lubricating oil.

**905** The strainers or filters are to be capable of being cleaned without stopping the oil supply to the engine.

**906** Where strainers are fitted on the discharge side of the lubricating oil pump, a relief valve in close circuit is to be fitted between the pump and the strainer.

### Drip Trays

**907** In ships built of wood, easily drained metal or metal-lined trays are to be fitted to prevent saturation of the woodwork by leakage from the engine and its filters.

### Lubrication of Bearings

**908** The arrangements for lubricating bearings and for draining crankcase and other oil sumps of main and auxiliary engines, gear cases, electric generators, motors and other running machinery are to be so designed that lubrication will remain efficient with the ship inclined from the normal at any angle up to 15 degrees transversely and when pitching 10 degrees longitudinally and when rolling up to 22½ degrees from the vertical.

**909** For details of the requirements relating to the lubrication of bearings of electric generators and motors, *see* M 107.

### Valves and Cocks

**910** Outlet valves and cocks on lubricating oil service tanks, other than double bottom tanks, situated in machinery spaces are to be capable of being closed locally and from positions outside the compartment which will always be accessible in the event of fire occurring in these spaces. Remote controls need only be fitted to outlet valves and cocks which are open in normal service and are not required for other outlets such as those on storage tanks. Indicators are to be provided at the valves and cocks and at the remote control positions to show whether they are open or closed.

In the case of very small tanks consideration will be given to the omission of remote controls.

### Cross-References

**911** For air and sounding pipes and gauge glasses, *see* E 404, E 413 and E 415.

## Section 10

## PUMPING ARRANGEMENTS FOR SHIPS NOT FITTED WITH PROPELLING MACHINERY

### Hand Pumps

**1001** Where auxiliary power is not provided, hand pumps are to be fitted in number and position as may be required for the efficient drainage of the ship.

The pumps are to be capable of being worked from the upper deck or from positions above the load water line which are at all times readily accessible.

The suction lift is not to exceed 7,3 metres, and is to be well within the capacity of the pump.

**1002** The sizes of the hand pumps are not to be less than given in the following table :

| Tonnage under Upper Deck | Hand Pumps | |
|---|---|---|
| | Diameter of barrel of bucket pump<br>Millimetres | Bore of suction pipe of bucket pumps and semi-rotary pumps<br>Millimetres |
| Not exceeding 500 tons ... | 100 | 50 |
| Above 500 tons but not exceeding 1,000 tons ... | 115 | 57 |
| Above 1,000 tons but not exceeding 2,000 tons ... | 125 | 65 |
| Above 2,000 tons ... ... | 140 | 70 |

Where the ship is closely subdivided into small watertight compartments 50 mm. bore suctions will be accepted.

### Power Pumps

**1003** In ships in which auxiliary power is available on board, power pump suctions are to be provided for dealing

with the drainage of tanks and of the bilges of the principal compartments.

The pumping arrangements are to be as required for self-propelled ships in so far as these requirements are applicable, duly modified to suit the size and service of the ship.

Details of the pumping arrangements are to be submitted for special consideration.

## Section 11

### PETROLEUM AND OTHER LIQUID CARGOES HAVING A FLASH POINT BELOW 65,5° C.

#### General

**1101** The following requirements are based on the assumption that the ships are of normal tanker type having the main propelling machinery aft.

Departures from normal type will require special consideration.

#### Cargo Oil System

**1102** A complete system of piping and pumps is to be fitted for dealing with the cargo oil.

**1103** Cargo pump rooms are to be enclosed by oiltight bulkheads and are to have no direct communication with machinery spaces.

**1104** Pumps for the purpose of filling or emptying the cargo oil tanks are to be used exclusively for this purpose, except as provided in 1107. They are not to have any connections to compartments outside the range of cargo oil tanks.

Cargo oil pumps are to be capable of being controlled from outside the pump rooms, as well as at the pumps.

**1105** The pumps are to be provided with effective escape valves which are to be in close circuit, i.e., discharging to the suction side of the pumps.

**1106** Expansion joints or bends are to be provided where necessary in the cargo pipe lines.

Terminal pipes, valves and other fittings in the cargo loading and discharging lines to which shore installation hoses are directly connected are to be of steel or other approved ductile material. They are to be of robust construction and strongly supported.

**1107** Provision is to be made for the bilge drainage of the cargo pump rooms by pump or bilge ejector suctions. The cargo pumps or cargo stripping pumps may be used for this purpose, provided the bilge suctions are fitted with screw-down non-return valves and, in addition, an isolating valve or cock be fitted on the pump connection to the bilge chest. The pump room bilges of small tankers may be drained by means of a hand pump having a 50 mm. bore suction.

Pump room suctions are not to enter machinery spaces.

**1108** Pump rooms are to be provided with ready means of access and adequate ventilation.

**1109** Ullage plugs or sighting ports are to be provided at each tank to enable the amount of ullage to be ascertained.

Ullage plugs or sighting ports should not be fitted in any enclosed space.

**1110** Provision is to be made for the gas freeing of the cargo oil tanks when the cargo has been discharged and for the ventilation and gas freeing of all compartments adjacent to cargo oil tanks.

**1111** Vapour pipes are to be fitted to cargo oil tanks and connected through shut-off cocks or valves or pressure-vacuum valves to a vapour line led up the mast or other post to a safe height above the weather deck. The outlets from these vapour mains are to be provided with readily renewable wire gauze or safety heads of approved types. If alternative means of dealing with the vapour are desired, details are to be submitted.

#### Bilge, Ballast, Oil Fuel and other Piping not within the Cargo Oil System

**1112** The pumping arrangements in the machinery space and at the forward end of the ship are to comply with the requirements for general cargo ships in so far as they are applicable and with the special requirements detailed in 1113 to 1117.

**1113** A separate power pump is to be fitted in a suitable compartment forward of the cargo tanks to deal with bilge drainage, water ballast and oil fuel pumping at the fore end of the ship.

In small tankers, a forward power pump may be dispensed with, provided suitable alternative arrangements are made, details of which are to be submitted.

**1114** Where deep cofferdams can be filled with water ballast, a ballast pump in the main engine room may be used for emptying the after cofferdam, provided the suction be led direct to the pump and not to an engine room pipe system. The ballast pump in the forward pump room may be used for emptying the forward cofferdam.

**1115** Cofferdams are not to have any direct connections to the cargo oil tanks or cargo oil lines.

Where intended to be dry compartments, after cofferdams adjacent to the pump room may be drained by a cargo pump, provided isolating arrangements are fitted in the bilge system as required by 1107; forward cofferdams may be drained by the bilge and ballast pump in the forward pump room. Alternatively, cofferdams may be drained by hand pumps or bilge ejectors.

Cofferdams are to be provided with sounding pipes and with air pipes led to the open. These air pipes are to be fitted with wire gauze diaphragms at their outlets.

**1116** Bilge, ballast, oil fuel and other piping connected to the pumps at the ends of the ship are not to pass through the cargo oil tanks or have any connection with these tanks.

Cargo oil pipes are not to pass through ballast or oil fuel tanks or through compartments which are external to the cargo oil system.

**1117** The oil fuel bunkering system is to be entirely separate from the cargo oil system.

### Steam and Exhaust Piping

**1118** Where heating coils are provided in the cargo oil tanks they are to be made and fitted under the usual conditions of survey and testing. (*See* E 334 to E 336, E 522 and E 601 to E 607.)

An observation tank is to be provided for the heating coil drains and is to be situated in a well ventilated and well lighted part of the machinery space remote from the boilers.

Spectacle flanges are to be provided in the main steam and exhaust pipes to the cargo oil heating system, at a suitable position forward of the machinery space bulkhead, so that the lines can be blanked off in circumstances where cargo oil does not require to be heated or where heating coils are not fitted in the tanks.

**1119** Steaming out and fire extinguishing connections for cargo oil tanks or cargo oil pipe lines are to be fitted with valves of non-return type and the main supply to these connections is to be fitted with a master valve placed in a readily accessible position clear of the tanks.

**1120** In the cargo pump rooms, drain pipes from steam or exhaust pipes or from the steam cylinders of the pumps are to terminate well above the level of the bilges.

### Motive Power of Cargo Oil Pumps

**1121** Where the cargo oil pumps are not driven by steam, plans of the arrangements for driving the pumps are to be submitted.

**1122** Where cargo pumps are driven by shafting which passes through a pump room bulkhead or deck, gastight glands with efficient means of lubrication are to be fitted to the shaft at the pump room plating.

### Auxiliary Machinery outside Main Engine Room

**1123** Internal combustion engines are not to be situated within pump rooms, cofferdams or other spaces liable to contain petroleum or other explosive vapours.

(For requirements for electrical equipment within such spaces, *see* M 16.)

## Section 12

## LIQUEFIED GASES

### General

**1201** The following requirements are intended primarily for liquefied Methane, Propane, Butane and other petroleum gases but may be applied to other liquefied gases with comparable properties and carrying hazards subject to special consideration in each case.

### PART 1

### LIQUEFIED PETROLEUM GASES CARRIED IN INDEPENDENT SPHERICAL OR CYLINDRICAL TYPE TANKS AT PRESSURES ABOVE 0,7 kg. per cm.$^2$ AND AT AMBIENT OR LOWER TEMPERATURES

### Plans

**1202** Plans showing filling, discharging, venting and inerting pipe arrangements, together with particulars of the intended cargo, maximum vapour pressure and minimum liquid temperature are to be submitted.

### Hold Drainage

**1203** Provision is to be made for the drainage of holds in which the cargo tanks are situated. Normal drainage is to be effected by hand pumps, bilge ejectors or other approved means. Hand pumps are to be made of gunmetal or other non-ferrous material and are to be fitted on deck having discharges directly overboard. Bilge ejectors are to be fitted in the holds and may be operated by steam or water.

**1204** In addition to the above requirements, bilge suctions as required by E 2 are to be provided for use in an emergency. These suctions are to be led direct to the bilge pump suction chest and are to be blanked off in normal

service by spectacle blank flanges in readily accessible positions in the machinery space. Screw-lift valves are to be fitted between the spectacle flanges and the bulkhead so that the pipes can be isolated if it is necessary to change over the spectacle flanges. Notice plates are to be fitted in the vicinity of the valves stating that the bilge suctions are not to be used except in case of grave emergency

A brass rod is to be provided for sounding the holds.

### Connections to Cargo Tanks

**1205** Cargo tanks are to be provided with the necessary connections for liquid and gas lines, relief valves, liquid level gauging devices, pressure gauges and thermometers.

**1206** All connections are to be situated above the weather deck and protected from damage.

### Shut-off Valves

**1207** Connections for filling and emptying the cargo tanks of liquid or gas are to be fitted with double shut-off valves: one is to be a manually operated shut-off valve and the other one of the following:—

(*a*) a remote controlled valve which is capable of being closed from the loading station and at least two other widely separated positions on the upper deck, or

(*b*) an excess flow valve which will close automatically and prevent the tank emptying in the event of a pipe breaking.

In the case of single purpose connections which are required only for the inlet of liquid or gas a non-return valve would be accepted in place of (*a*) or (*b*) above.

Shut-off valves are to be fitted with legible nameplates in prominent positions.

### Pressure Relief Valves

**1208** Each cargo tank is to be protected by one or more pressure relief valves of approved design and capacity discharging into a vapour relief main led up the mast or other post to a safe height above the weather deck and well removed from possible sources of ignition.

The relief valves should be of sufficient capacity to discharge the vapours formed by exposure of the cargo tank walls to fire. Calculations on which the area of the valves are based are to be submitted.

In every case the combined discharge capacity of the pressure relief valves is to be sufficient to prevent a rise of pressure in the tank to more than 10 per cent above the design vapour pressure.

The discharge capacity of a pressure relief valve is to be established by type tests carried out in the presence of the Surveyors or by an independent authority recognised by the Society.

Pressure relief valve connections are to be attached to the tanks near the highest part of the vapour space.

Shut-off valves are not to be fitted between the tanks and the pressure relief valves unless there are two or more relief valves per tank and the shut-off arrangements are so devised that pressure relief valves having the required discharge capacity are always in communication with the tank.

Shut-off valves are not to be fitted between the pressure relief valves and the vapour relief main outlet.

Each pressure relief valve is to be tested in the presence of the Surveyors to demonstrate that it commences to discharge at a pressure not more than 3 per cent above the maximum vapour pressure for which the tanks have been approved.

### Vacuum Relief Valves

**1209** Consideration should be given to the ability of the cargo tanks to withstand any vacuum which may arise in service or when the tanks are being gas freed. Where necessary, vacuum relief valves are to be fitted and vacuum relief obtained from an inert gas system or the atmosphere.

### Vapour Relief Systems

**1210** The vapour relief main is to have a cross-sectional area equal to the combined area of the branch vapour relief pipes, but if there are three or more cargo tanks the following percentage reductions in the area of the vapour relief main will be allowed:—

| | | | |
|---|---|---|---|
| 3 cargo tanks | | 10% | reduction |
| 4 | ,, | ,, 20% | ,, |
| 5 | ,, | ,, 30% | ,, |
| 6 | ,, | ,, 40% | ,, |
| or more | | | |

The vapour relief system outlet is to be arranged to discharge the gases in a direction above the horizontal and the outlet is to be fitted with a flameproof wire gauze diaphragm and protected from the weather. Suitable drainage arrangements for condensate water are to be provided for the vapour relief lines.

### Level Gauges

**1211** Liquid level gauging devices are to be of approved type and are to indicate the maximum level to which the tank may be filled having regard to the nature of the cargo and its temperature.

### Pressure Gauges

**1212** Pressure gauges are to be marked with the working pressure of the tank. Pressure gauge connections are to be fitted with a manually operated shut-off valve.

### Cargo Piping System

**1213** A complete system of piping, pumps, compressors, etc., is to be provided for dealing with the cargo. The system is to be used exclusively for this purpose and is not to have connections to compartments outside the range of the cargo tanks.

All piping in the cargo handling system is to be situated above the weather deck.

**1214** All materials used in the piping systems must be suitable for the proposed service. Where the operating metal temperature is below 0° C., specifications of the materials for pipes and fittings giving chemical composition and mechanical properties at the service temperature are to be submitted for approval.

**1215** All piping, valves and fittings are to be suitable for the maximum pressure to which the system may be subjected, but not, in any case, less than a pressure of 10,5 kg. per cm.$^2$.

Piping subject to pressure is to be of seamless or other approved type and is to comply with the requirements of E 5.

Valves and fittings are to be of steel or other approved ductile material.

**1216** Joints may be of butt-welded or flanged type. Couplings of approved type may be used for joints 38 mm. diameter or smaller. Low grade screwed joints are not acceptable.

**1217** Provision is to be made in the pipe lines for the effects of expansion and contraction. If expansion pieces are used they are to be of the bellows type. All piping is to be suitably supported and secured.

**1218** Low temperature pipes are to be protected against external corrosion, adequately insulated and provided with temperature isolation from the hull. Drip trays are to be fitted where cargo leakage or spillage is likely to occur.

**1219** Sections of piping which may contain liquid gas and which can be isolated are to be provided with relief valves discharging to the vapour relief main or other safe position.

**1220** Connections are to be provided so that the cargo tanks and the cargo handling system can be purged with an inert gas. Provision is also to be made for the gas-freeing of the cargo tanks.

**1221** Terminal pipes, valves and fittings in the cargo handling system, to which shore installation hoses are directly connected, are to be of robust construction and strongly supported.

Suitable arrangements are to be provided for relieving the liquid and gas lines of internal pressure before the shore installation hoses are disconnected.

### Earthing of Tanks and Pipes

**1222** Where tanks and pipes are separated from the hull structure by insulating materials they are to be effectively earthed to the hull by at least two earthing connections as a precaution against the effects of static charges.

### Cargo Pumps and Gas Compressors

**1223** Pumps and compressors may be installed on the open deck provided they are suitably located and protected from mechanical damage. Alternatively, the pumps and compressors may be fitted in a well-ventilated compartment outside the machinery space. This compartment is to be treated as a dangerous space to which the requirements of M 16 for electrical equipment are applicable.

**1224** Where pumps and compressors are driven by shafting which passes through a bulkhead, gastight glands with efficient means of lubrication are to be fitted to the shafts in way of the bulkhead.

**1225** The pumps are to be fitted with relief valves if they are capable of developing a discharge pressure greater than the design pressure of the piping system. The relief valves are to discharge to the suction side of the pumps.

**1226** Compressors are to be fitted with relief valves discharging to the vapour relief main, or other safe position. The relief valves are to be so proportioned and adjusted that the accumulation with the outlet valves closed will not exceed 10 per cent of the maximum working pressure.

**1227** The pumps and compressors are to be capable of being stopped from the loading station and from a position outside the range of the cargo tanks.

### Refrigeration Equipment and Piping

**1228** Where the cargo is refrigerated or the boil-off is re-liquefied, the arrangements will be specially considered. In ships classed for unrestricted service the capacity of the refrigerating machines is to be based on a sea temperature of 30° C. and on an ambient air temperature of 45° C. Two or more refrigerating units are to be provided of capacity sufficient to maintain the liquid cargo at the carrying temperature with any one unit out of use.

## PART 2

## LIQUEFIED METHANE AND PETROLEUM GASES CARRIED IN INDEPENDENT RECTANGULAR TYPE TANKS AT PRESSURES OF 0,7 kg. per cm.$^2$ OR LESS AND AT TEMPERATURES BELOW AMBIENT

The following paragraphs of Part 1 are applicable:—

| | |
|---|---|
| Plans ... ... ... ... | 1202 |
| Connections to Cargo Tanks ... | 1205 and 1206 |
| Pressure Relief Valves ... ... | 1208 |
| Vapour Relief System ... ... | 1210 |
| Cargo Piping System ... ... | 1214 to 1221 inclusive |
| Earthing of Tanks and Pipes ... | 1222 |
| Refrigeration Equipment and Piping ... ... ... ... | 1228 |

### Shut-off Valves

**1229** Each cargo tank is to be provided with separate connections for cooling down, filling and discharge purposes. These connections are to have shut-off valves or cocks manually controlled and fitted with legible nameplates in a prominent position.

Filling connections are to be provided with internal pipes led to the bottom of the tanks.

### Vacuum Relief Valves

**1230** Each cargo tank is to be provided with means for relieving vacuum based on the maximum liquid unloading rate from the tank. Vacuum relief may be obtained from a supply of cargo gas, an inert gas system or the atmosphere. Where submerged electric pumps are used, the vacuum valves are to be connected to an inert gas supply.

### Level Gauges

**1231** An approved liquid level gauging device of the closed type is to be provided for each tank. This gauge should be arranged to give audible and visible warning of the high and low liquid levels in the tank.

An independent high level alarm device is also to be provided for each tank which, besides giving audible and visible warning of over-filling, is capable of closing the terminal valve at the cargo loading station.

Liquid level gauging and alarm devices are to be adequately protected against damage.

### Pressure Gauges

**1232** Means are to be provided for indicating the pressure in each cargo tank and containment space.

### Thermometers

**1233** Thermometers are to be of the remote reading type and are to be marked with the mimimum permitted carrying temperature for the tank.

### Instrument and Control Rooms

**1234** Gas detection, pressure recording, safety and alarm devices, etc., are to be installed in a well ventilated room in an approved position.

Where gas detecting devices are fitted in a room containing electrical equipment which is not intrinsically safe, the arrangements are to be such that there is no possibility of gas leakage reaching the electrical equipment. Details are to be submitted.

### Cargo Pumping System

**1235** A complete pumping system is to be provided for dealing with the cargo. The system is to be used exclusively for this purpose and is not to have connections to compartments outside the range of the cargo tanks.

Terminal valves at the loading station are to be capable of being closed locally and from at least two other widely-separated positions on the upper deck.

All piping in the cargo pumping system is to be situated above the weather deck.

### Emergency Discharge of Cargo

**1236** Where cargo tanks are surrounded by void spaces, provision is to be made for draining such spaces in the event of tank leakage or rupture.

Arrangements are to be made so that the liquid cargo can be discharged overboard in an emergency. The discharge nozzle should preferably be at the stern of the ship and so designed that the liquid discharge will reach the water as far from the ship as possible.

### Cargo Pumps

**1237** All cargo pumps are to be capable of being stopped from the loading station and from a position outside the range of the cargo tanks. The pumps are to be fitted with relief valves if they are capable of developing a discharge pressure greater than the design pressure of the piping system. The relief valves are to discharge to the suction side of the pump.

Stand-by means for pumping out each cargo tank are to be provided.

**1238** In the case of deep well pumps driven from positions above the cargo tanks, gastight glands with efficient means of lubrication are to be provided where the driving shafts enter the tanks.

**1239** If the cargo pumps are driven by submerged electric motors, the arrangements will be subject to special consideration and must ensure that under all conditions air will not be admitted to the cargo tanks.

*21st May, 1964*

**Cross-reference**

**1240** Cargo tanks are to be constructed as required by J 25 or D 71 whichever is applicable.

Ventilation arrangements are to comply with ... D 72

Electrical arrangements are to comply with ... M 16

The use of Methane as fuel for propulsion purposes ... ... ... ... ... *see* R (A)

# Chapter F

# FIRE PROTECTION, DETECTION AND EXTINCTION

## PART 1

## FIRE DETECTION AND EXTINCTION IN PASSENGER, CARGO AND OTHER SHIPS

### Section 1

#### GENERAL

**101** The requirements of Part 1 of this Chapter apply to passenger and cargo ships to be classed for unrestricted service.

**102** While the requirements satisfy the regulations of the International Convention for the Safety of Life at Sea, 1960, attention should also be given to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered. Compliance with these statutory requirements may be accepted as meeting the requirements of this Chapter.

**103** Consideration will be given to special cases where the arrangements are equivalent to those required by these Rules. Consideration will also be given to fire extinguishing equipment and arrangements for small ships and ships to be classed for restricted or special service.

**104** Fire fighting appliances—hoses, extinguishers, gas cylinders, emergency pumps, breathing apparatus, fireman's axe, etc.—which have been approved by a National Authority as complying with the regulations of the International Convention for Safety of Life at Sea, 1960, may be accepted as meeting the requirements of this Chapter.

### Section 2

#### PUMPS, WATER SERVICE PIPES, HYDRANTS AND HOSES

**Total Capacity of Fire Pumps**

**201** In a passenger ship, the required fire pumps of F 4 are to be capable of delivering for fire fighting purposes a quantity of water not less than two-thirds of the total quantity required to be dealt with by the bilge pumps when employed for bilge pumping. (*See* E 239 for number and capacity of bilge pumps.)

**202** In a cargo ship, the required fire pumps of F 5, other than the emergency pump (if any), are to be capable of delivering for fire fighting purposes a quantity of water not less than two-thirds of the total quantity required to be dealt with by the bilge pumps when employed for bilge pumping, except that in cargo ships the total required capacity of the fire pumps need not exceed 180 tons (180 metres$^3$) per hour. (*See* E 205 for number and capacity of bilge pumps.)

**Fire Pumps**

**203** Sanitary, ballast, bilge or general service pumps may be accepted as fire pumps, provided that they are not normally used for pumping oil and that if they are subject to occasional duty for the transfer or pumping of fuel oil, suitable change-over arrangements are fitted.

In ships classed for navigation in ice the fire pump sea inlet valves are to be provided with ice clearing arrangements as required by H 809 and H 811.

**204** Any pump designated as a fire pump (other than any emergency pump required by F 505) is to have a capacity not less than 80 per cent of the total required capacity divided by the number of required fire pumps and in any event is to be capable of delivering at least the two required jets of water. Any deficiency in capacity of one of the fire pumps is to be made good by excess capacity of the other fire pumps. These fire pumps are to be capable of supplying the fire main system under the required conditions.

Where more pumps than required are installed their capacities will be specially considered.

**205** Relief valves are to be provided in conjunction with all fire pumps if the pumps are capable of developing a pressure exceeding the design pressure of the water service

pipes, hydrants and hoses. These valves are to be so placed and adjusted as to prevent excessive pressure in any part of the fire main system.

**Fire Main**

**206** The diameter of the fire main is to be based on the required capacity of two fire pumps and the diameters of the water service pipes are to be sufficient to ensure an adequate supply of water for the simultaneous operation of at least two fire hoses. In general, the diameter of the fire main should be not less than that required by the following formula but is to be in no case less than 2 inches (50 mm.):—

$$d = \frac{L}{100} + 1 \qquad d_1 = \frac{L_1}{1,2} + 25$$

When $d$ = internal diameter of the fire main, in inches,

$d_1$ = internal diameter of the fire main, in millimetres,

$L$ = rule length of the ship, in feet,

$L_1$ = rule length of the ship, in metres.

The diameter of the fire main need not exceed 5 inches (127 mm.) in cargo ships and 7 inches (178 mm.) in passenger ships.

**207** The fire main is to be situated outside the machinery spaces and the discharge line or lines from the fire pumps are to be fitted with isolating valves at the connections to the fire main. Where the machinery space is situated amidships isolating valves are also to be provided in the fire main so that the hydrants at both ends of the ship may be used simultaneously or separately.

**208** The wash deck line may be used as a fire main provided the requirements of this Section are satisfied.

**209** All water pipes for fire extinguishing are to be provided with drain valves for use in frosty weather. The valves are to be located where they will not be damaged by cargo.

**Number and Position of Hydrants**

**210** The number and position of the hydrants are to be such that at least two jets of water not emanating from the same hydrant, one of which is to be from a single length of hose, may reach any part of the ship. In ships of 1000 tons gross and over two hydrants are to be provided in the machinery spaces: in smaller ships one hydrant will be accepted.

**Pipes and Hydrants**

**211** Materials readily rendered ineffective by heat are not to be used for fire mains. Where steel pipes are used they are to be galvanised internally and externally. Cast iron pipes are not acceptable. The pipes and hydrants are to be so placed that the fire hoses may be easily coupled to them. In ships where deck cargo may be carried, the positions of the hydrants are to be such that they are always readily accessible and the pipes are to be arranged as far as practicable to avoid risk of damage by such cargo. Unless there is provided one hose and nozzle for each hydrant in the ship there shall be complete interchangeability of hose couplings and nozzles.

**212** Cocks or valves are to be fitted in such positions on the pipes that any of the fire hoses may be removed while the fire pumps are at work.

**Fire Hoses**

**213** Fire hoses are to be of leather, seamless hemp, close weave flax canvas, or other approved material. The hoses are to be sufficient in length to project a jet of water to any of the spaces in which they may be required to be used. Their length in general is not to exceed 60 feet (18,3 metres). Each hose is to be provided with a nozzle and the necessary couplings. Fire hoses, together with any necessary fittings and tools, are to be kept ready for use in conspicuous positions near the water service hydrants or connections.

**Nozzles**

**214** The nozzles used for extinguishing fires other than oil fires are to have a bore of not less than $\frac{1}{2}$ inch (12 mm.). For accommodation and service spaces, a nozzle size of $\frac{1}{2}$ inch (12 mm.) will normally be adequate but for machinery spaces and exterior locations $\frac{1}{2}$, $\frac{5}{8}$ or $\frac{3}{4}$ inch (12, 16 or 20 mm.) nozzles may be adopted so as to make full use of the maximum discharge capacity of the fire pumps. The jet throw at any nozzle is to be about 40 feet (12,2 metres). Dual purpose nozzles for jet or fog may be adopted.

**International Shore Connection**

**215** The international shore connection required by F 408 and F 509 is to be suitable for a working pressure of 150 pounds per square inch (10,5 kg. per cm.$^2$). It is to have on one side a flat faced flange with dimensions as shown in Fig. 1, and on the other side a permanently attached coupling that will fit the ship's hydrants and hose. The connection is to be kept aboard the ship together with a gasket suitable

for 150 pounds per square inch (10,5 kg. per cm.$^2$) service, together with four $\frac{5}{8}$ inch (16 mm.) bolts, 2 inches (50 mm.) in length, and eight washers.

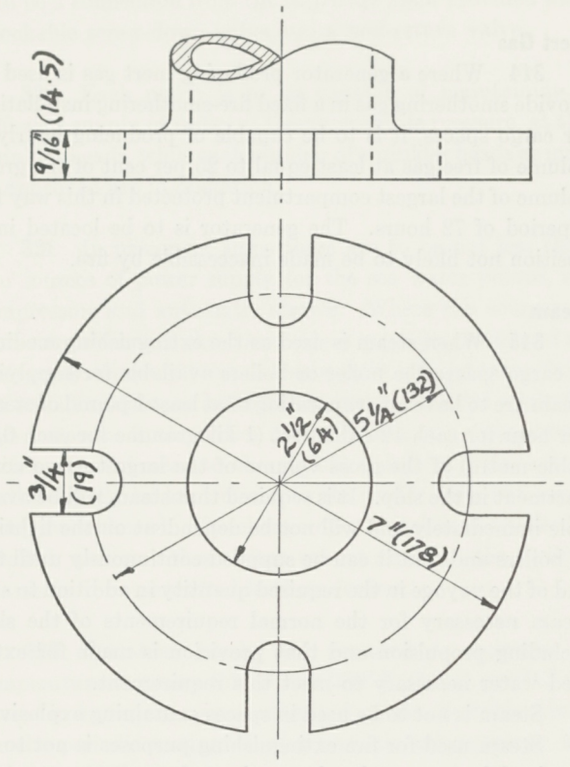



Fig. 1

## Section 3

### FIRE EXTINGUISHERS AND EXTINGUISHING SYSTEMS

**Fire Extinguishers (Portable and Non-Portable)**

**301** All fire extinguishers are to be approved types. If considered necessary, the Committee may require the makers to produce evidence from a recognised independent testing authority regarding the suitability of their appliances.

**302** The extinguishers required for use in the machinery spaces of ships burning oil as fuel are to be of a type discharging froth, carbon dioxide gas, dry powder, or other approved medium suitable for extinguishing oil fires.

Fire extinguishers containing an extinguishing medium which either itself or when in use gives off gases harmful to persons are not to be used. For radio rooms and switchboards extinguishers containing not more than 1 quart (1,136 litres) of carbon tetrachloride or similar media may be permitted subject to such extinguishers being additional to any required by F 4 and F 5.

**303** The capacity of required portable fluid extinguishers is not to be more than 3 gallons (13,5 litres) and not less than 2 gallons (9 litres). Other extinguishers are not to be in excess of the equivalent portability of the 3 gallon (13,5 litre) fluid extinguisher and are not to be less than the fire extinguishing equivalent of a 2 gallon (9 litre) fluid extinguisher.

**304** A spare charge is to be provided for each required portable fire extinguisher which can be readily re-charged on board. If this cannot be done, duplicate extinguishers are to be provided.

**305** One of the portable fire extinguishers intended for use in any space is to be stowed near the entrance to that space.

**Acceptable Equivalents**

**306**

| Froth | Carbon Dioxide |
|---|---|
| 30 gal. (136 litres) | 100 lb. (45 kg.) |
| 10 gal. (45 litres) | 35 lb. (16 kg.) |
| Portable | 10 lb. (4,5 kg.) |

**Fire-Smothering Gas or Steam for Machinery and Cargo Spaces**

**307** Where provision is made for the injection of gas into machinery spaces or gas or steam into cargo spaces for fire extinguishing purposes, the necessary pipes for conveying the gas or steam are to be provided with control valves or cocks which are to be so placed that they will be easily accessible and not readily cut off from use by an outbreak of fire. These control valves or cocks are to be so marked as to indicate clearly the compartments to which the pipes are led. Suitable provision is to be made to prevent inadvertent admission of the gas or steam to any compartment. Where cargo spaces, fitted with smothering equipment for fire protection, are used as passenger spaces the smothering connections are to be blanked during service as a passenger space. Blank flanges fitted in gas or steam distribution pipes are to be of the "spectacle" type. The nuts for the securing bolts are to be of non-corrodible metal.

**308** The piping is to be of adequate size and so arranged to provide effective distribution of fire-smothering gas or steam. In holds exceeding 60 feet (18,3 metres) in length, there are to be at least two pipes, one of which is to be fitted in the forward part and one in the after part; the steam pipes are to be led well down in the space as remote as possible from the shell. Separate pipes are to be provided

for lower hold and 'tween decks. All pipes are to be arranged to be self-draining and are not to be led through refrigerated spaces unless the pipes are specially insulated. Steel distribution pipes are to be galvanised internally and externally and are not to be smaller than $\frac{3}{4}$ inch (20 mm.) bore for carbon dioxide and 1 inch (25 mm.) bore for steam and inert gas.

In tankers, the piping system is to be so arranged that the gas or steam will be distributed over the surface of the cargo. *See also* F 512.

**Carbon Dioxide Gas**

**309** When carbon dioxide is used as the extinguishing medium in cargo spaces, the quantity of gas available is to be sufficient to give a minimum volume of free gas equal to 30 per cent of the gross volume of the largest cargo compartment in the ship which is capable of being sealed.

**310** When carbon dioxide is used as an extinguishing medium for spaces containing boilers or internal combustion type machinery, the quantity of gas carried is to be sufficient to give a minimum volume of free gas equal to the larger of the following, either:—

(1) 40 per cent of the gross volume of the largest space, the volume to include the casing up to the level at which the horizontal area of the casing is 40 per cent or less of that of the space concerned; or

(2) 35 per cent of the entire volume of the largest space including the casing;

provided that the above mentioned percentages may be reduced to 35 per cent and 30 per cent respectively for cargo ships of less than 2000 tons gross; provided also that if two or more spaces containing boilers or internal combustion type machinery are not entirely separate they are to be considered as forming one compartment.

**311** When carbon dioxide is used as an extinguishing medium both for cargo spaces and for spaces containing boilers or internal combustion type machinery the quantity of gas need not be more than the maximum required either for the largest cargo compartment or machinery space. The volume of gas is to be calculated at 9 cubic feet to the pound (0,56 cubic metres to the kilogramme).

**312** When carbon dioxide is used as the extinguishing medium for spaces containing boilers or internal combustion type machinery the fixed piping system is to be such that 85 per cent of the gas can be discharged into the space within 2 minutes.

**313** The gas cylinders and main controls are to be located to the Surveyors' satisfaction in a cool and well ventilated position, not likely to be made inaccessible by fire. Provision is to be made for changing the cylinders and checking their contents by weighing or other approved means. Operating instructions are to be displayed at the controls.

**Inert Gas**

**314** Where a generator producing inert gas is used to provide smothering gas in a fixed fire-smothering installation for cargo spaces, it is to be capable of producing hourly a volume of free gas at least equal to 25 per cent of the gross volume of the largest compartment protected in this way for a period of 72 hours. The generator is to be located in a position not likely to be made inaccessible by fire.

**Steam**

**315** When steam is used as the extinguishing medium in cargo spaces the boiler or boilers available for supplying steam are to have an evaporation of at least 1 pound of steam per hour for each 12 cubic feet (1 kilogramme for each 0,75 cubic metre) of the gross volume of the largest cargo compartment in the ship. It is required that steam will be available immediately and will not be dependent on the lighting of boilers and that it can be supplied continuously until the end of the voyage in the required quantity in addition to any steam necessary for the normal requirements of the ship including propulsion and that provision is made for extra feed water necessary to meet this requirement.

Steam is not to be used in spaces containing explosives.

Steam used for fire extinguishing purposes is not to be obtained from a supply of super-heated steam.

**Audible Alarms**

**316** Means are to be provided whereby audible warning is given automatically before fire-smothering gas can be released into the machinery space and any other working space.

**Automatic Sprinkler Systems**

**317** Any automatic water sprinkler system for fire protection is to be designed for immediate use at any time, so that no action on the part of the crew is necessary to set it in operation. Where such a system is fitted, it is to be kept charged at the necessary pressure and is to have provision for a continuous supply of water. The distribution pipes are to be of steel or other approved material of adequate strength and the mains and their branches up to the section control points, if of steel, are to be galvanized internally and externally.

**318** The system is to be sub-divided into an approved number of sections, and automatic alarms are to be provided to indicate at one or more suitable points or stations the occurrence or indication of fire, and its location.

**319** The pump or pumps to provide the discharge from sprinkler heads are to be so connected as to be brought into action automatically by a pressure drop in the system. There is to be a connection from the ship's fire main provided with a lockable screw-down valve and a non-return valve.

**320** Each pump is to be capable of maintaining a sufficient supply of water at the appropriate pressure, at the sprinkler heads, while such number of sprinkler heads as may be approved are in operation.

**321** In passenger ships there are to be not less than two sources of power supply for the sea water pumps, air compressors and automatic alarms. Where the sources of power are electrical, these are to be a main generator and an emergency source of power. One supply is to be taken from the main switchboard by separate feeders reserved solely for that purpose. Such feeders are to be run to a change-over switch situated near to the sprinkler unit and the switch shall normally be kept closed to the feeder from the emergency switchboard. The change-over switch is to be clearly labelled, and no other switch except those at the switchboards is to be permitted in these feeders.

**322** Sprinkler heads are required to operate at temperatures between 155° F. and 200° F. (68° C. and 93° C.) except in drying rooms and other hot spaces. Suitable means for the periodic testing of all automatic arrangements are to be provided.

**323** Where a sprinkler system of fire protection is employed in a ship the superstructure of which is constructed in aluminium alloy, the whole unit including the sprinkler pump, tank and air compressor is to be situated in an approved position reasonably remote from the boiler and machinery spaces. If the feeders from the emergency generator to the sprinkler unit pass through any space constituting a fire risk the cables are to be of a fireproof type.

### Fixed Froth Fire Extinguishing System

**324** Any required fixed froth fire extinguishing system is to be able to discharge a quantity of froth sufficient to cover to a depth of 6 inches (150 mm.) the largest area over which oil fuel is liable to spread.

**325** Such a system is to be controlled from an easily accessible position or positions, outside the space to be protected, which will not be readily cut off by an outbreak of fire. The distribution pipes are to be of steel galvanised internally and externally.

### Fire Detection Systems

**326** All required fire detection systems are to be capable of automatically indicating the presence or indication of fire and its location. Indicators are to be centralised either on the bridge or in other control stations which are provided with a direct communication with the bridge. The indicators may be distributed among several stations subject to approval by the Surveyors.

**327** In passenger ships electrical equipment used in the operation of required fire detection systems is to have two separate sources of power, one of which should be an emergency source.

**328** The alarm system is to operate both audible and visible signals at the main stations referred to in 326. Detection systems for cargo spaces need not have audible alarms.

### Fixed Pressure Water-Spraying Systems for Engine Rooms and Boiler Rooms

**329** Fixed pressure water-spraying systems for boiler rooms with oil fired boilers and engine rooms with internal combustion type machinery are to be provided with spraying nozzles of an approved type.

**330** The number and arrangement of the nozzles are to be to the satisfaction of the Surveyors and be such as to ensure an effective distribution of water in the spaces to be protected. Nozzles are to be fitted above bilges, tank tops and other areas over which oil fuel is liable to spread and also above oil fuel settling and service tanks, heaters, pumping units, purifiers and other main fire hazards in the boiler and engine rooms.

**331** The system may be divided into sections, the distribution manifolds of which are to be operated from easily accessible positions outside the spaces to be protected and which will not be readily cut off by an outbreak of fire.

**332** The system is to be kept charged at the necessary pressure and the pump supplying the water for the system is to be put automatically into action by a pressure drop in the system.

**333** The pump is to be capable of simultaneously supplying at the necessary pressure all sections of the system in any one compartment to be protected. The pump and its controls are to be installed outside the space or spaces to be protected. It is not to be possible for a fire in the space or spaces protected by the water-spraying system to put the system out of action.

**334** Special precautions are to be taken to prevent the nozzles from becoming clogged by impurities in the water or corrosion of piping, nozzles, valves and pump.

### Fireman's Outfit

**335** A fireman's outfit is to consist of a breathing apparatus, a lifeline, a safety lamp and an axe, as described in this paragraph.

The breathing apparatus is to be of an approved type and may be either (1) or (2):—

(1) A smoke helmet or smoke mask which is to be provided with a suitable air pump and a length of air hose sufficient to reach from the open deck, well clear of hatch or doorway, to any part of the holds or machinery spaces. If, in order to comply with this requirement, an air hose exceeding 120 feet (36,6 metres) in length would be necessary, a self-contained breathing apparatus is to be substituted or provided in addition.

(2) A self-contained breathing apparatus which is to be capable of functioning for a period of at least 30 minutes. Spare bottles are to be provided except where facilities for re-charging the bottles are available on board ship.

Each breathing apparatus is to have attached to its belt or harness, by means of a snaphook, a fireproof lifeline of sufficient length and strength.

The safety lamp (hand lantern) is to be of an approved type. Such safety lamps are to be electric, and are to have a minimum burning period of three hours.

The axe is to have an insulated handle.

### Closing of Openings and Control of Fans

**336** Provision is to be made for closing all openings which might admit air to machinery spaces, to other spaces where there is risk of an oil fire and to cargo spaces protected by fire-smothering systems. Skylights and ventilators of machinery spaces including pump rooms in tankers are to be capable of being shut from deck or from a safe position outside these spaces. Provision is to be made for rapidly stopping all fans from positions outside such spaces.

### Cross-references

**337** For precautionary arrangements relating to oil leakage and outbreaks of fire *see:*—

D 2025–D 2028, D 2216, D 2331, D 2401, E 310, E 315–E–319, E 330–E 333, E 337–E 343, E 403–E 405, E 407 and E 413–E 414.

## Section 4

## REQUIREMENTS FOR PASSENGER SHIPS

### Fire Detection and Alarms

**401** Manual fire alarms are to be fitted throughout the passenger and crew accommodation to enable the fire patrol to give an alarm immediately to the bridge or fire control station.

**402** A fire alarm or fire detecting system is to be provided which will automatically indicate at one or more suitable points or stations, where it can be most quickly observed by officers and crew, the presence or indication of fire and its location in any parts of the ship such as cargo spaces, baggage and store rooms which are not accessible to the patrol system, except where the ship is engaged on voyages of such short duration that it would be unreasonable to apply this requirement.

### Fire Pumps and Water Service Pipes

**403** A passenger ship is to be provided with fire pumps, water service pipes, hydrants and hoses complying with F 2 and with the following requirements:—

(1) A passenger ship of 4000 tons gross and over is to be provided with at least three independently driven fire pumps and every passenger ship of less than 4000 tons gross with at least two such fire pumps.

(2) In a passenger ship of 1000 tons gross and over the arrangement of sea connections, pumps and sources of power for operating them is to be such as to ensure that a fire in any one compartment will not put all the fire pumps out of action.

(3) In a passenger ship of less than 1000 tons gross, if a fire in any one compartment could put all the pumps out of action, an emergency fire pump having a capacity of not less than 15 tons (15 metres$^3$) per hour is to be provided.

### Fire Hydrants, Hoses and Nozzles

**404** A passenger ship is to be provided with such number of fire hoses as are appropriate and sufficient for the type of ship. There is to be at least one fire hose for each of the hydrants required by F 210, and these hoses are to be used only for the purposes of extinguishing fires or testing the fire extinguishing apparatus at fire drills and surveys.

**405** In accommodation, service and machinery spaces, the number and position of hydrants are to be such that the requirements of F 210 may be complied with when all watertight doors and all doors in main vertical zone fire bulkheads are closed.

**406** In a passenger ship the arrangements are to be such that at least two jets of water can reach any part of any cargo space when empty.

**407** All hydrants in the machinery spaces of passenger ships with oil-fired boilers, steam turbine or internal combustion type propelling machinery are to be fitted with hoses having in addition to the nozzles required in F 214 nozzles suitable for spraying water on oil, or alternatively, dual purpose nozzles. One such hydrant is to be provided in the shaft tunnel adjacent to the engine room watertight door.

**International Shore Connection**

**408** A passenger ship of 1000 tons gross and over is to be provided with at least one international shore connection, complying with F 215. Facilities are to be available enabling such a connection to be used on either side of the ship.

**Portable Fire Extinguishers in Accommodation and Service Spaces**

**409** A passenger ship is to be provided in accommodation, radio rooms and service spaces with such approved portable fire extinguishers as the Surveyors may deem to be appropriate and sufficient. In galleys and their sub-division, one or more portable extinguishers suitable for dealing with fires in oil-fired or electric cooking equipment are to be provided.

**Fixed Fire-Smothering Arrangements in Cargo Spaces**

**410** The cargo spaces of passenger ships of 1000 tons gross and over are to be protected by a fixed fire-smothering gas system complying with F 3.

**411** Where a passenger ship is engaged on voyages of such short duration that it would be unreasonable to apply the requirements of 410 and also in passenger ships of less than 1000 tons gross, the necessity for fire-smothering arrangements in cargo spaces will be specially considered.

**Fire Extinguishing Appliances in Boiler Rooms, etc.**

**412** In spaces where main or auxiliary oil-fired boilers are situated, or in spaces containing oil fuel units or settling tanks, a passenger ship is to be provided with any one of the following fixed fire extinguishing installations complying with F 3:—

(1) A pressure water spraying system.
(2) A fire-smothering gas installation.
(3) A fixed froth installation supplemented, if necessary, by a fixed or mobile arrangement for pressure water or froth spraying to fight fire above the floor plates.

In each case if the engine and boiler rooms are not entirely separate, or if fuel oil can drain from the boiler room into the engine room bilges, the combined engine and boiler rooms are to be considered as one compartment.

**413** There are to be at least two approved portable extinguishers discharging froth or other approved medium suitable for extinguishing oil fires, in each firing space in each boiler room and each space in which a part of the oil fuel installation is situated.

There is to be not less than one approved froth type extinguisher of at least 30 gallons (136 litres) capacity or equivalent in each boiler room. These extinguishers are to be provided with hoses on reels suitable for reaching any part of the boiler room and spaces containing any part of the oil fuel installations.

**414** In each firing space there is to be a receptacle containing at least 10 cubic feet (0,28 metre$^3$) of sand, sawdust impregnated with soda or other approved dry material and a scoop for distributing this material. Alternatively, an approved portable extinguisher may be substituted therefor.

**Fire Fighting Appliances in Spaces containing Internal Combustion Type Machinery**

**415** Where internal combustion engines or gas turbines are used, either (1) for main propulsion or (2) for auxiliary purposes associated with a total power not less than 1000 B.H.P., a passenger ship is to be provided with the following arrangements A and B:—

(A) There is to be one of the fixed arrangements 1, 2 or 3 required by 412.

(B) There is to be in each engine space one approved froth type extinguisher of not less than 10 gallons (45 litres) capacity or equivalent and also one approved portable froth type extinguisher for each 1000 B.H.P. of the engines or part thereof; but the total number of portable extinguishers so supplied is to be not less than two and need not exceed six.

**Fire Fighting Arrangements in Spaces containing Steam Machinery**

**416** Provision is to be made for extinguishing lubricating oil fires in spaces which are separated from boiler rooms by watertight bulkheads when these spaces contain steam turbines or enclosed forced lubricated steam engines using superheated steam. Equipment not less effective than detailed in 415 (B) is to be provided to the Surveyors' satisfaction.

**Fireman's Outfits**

**417** A passenger ship is to carry at least two fireman's outfits each complying with the requirements of F 335. Where the ship exceeds 10000 tons gross at least three outfits are to be carried and where it exceeds 20000 tons gross at least four outfits are to be carried. These outfits are to be kept in widely separated places ready for use.

## Section 5

### REQUIREMENTS FOR CARGO SHIPS

**Fire Pumps and Water Service Pipes**

**501** All cargo ships are to be provided with fire pumps, water service pipes, hydrants and hoses complying in general with F 2.

**502** In cargo ships of less than 150 tons gross, one power pump is to be available for fire extinguishing service. If the ship has a restricted class for harbour or river service a suitable hand pump may be substituted for the power pump.

**503** In cargo ships of 150 tons gross and over, but less than 1000 tons gross, not less than two power pumps are to be provided, one of which is to be an independent pump.

**504** In cargo ships of 1000 tons gross and over not less than two independently driven power pumps are to be provided.

**505** In a cargo ship of 1000 tons gross and over if a fire in any one compartment could put all the pumps out of action there is to be an alternative means of providing water for fire fighting. This alternative means is to be a fixed emergency pump independently driven by a compression ignition engine, or other approved means and having a capacity of not less than 15 tons (15 metres$^3$) per hour in ships of 1000 tons gross to 2000 tons gross, and not less than 25 tons (25 metres$^3$) per hour for ships above 2000 tons gross. This emergency pump is to be capable of supplying two jets of water to the satisfaction of the Surveyors. The pump should be located remote from the machinery space; e.g. in ships with machinery amidships the pump should be installed in the tunnel or steering gear compartment, and in ships with machinery aft the pump preferably should be located forward. The pump is to be provided with its own sea suction and a discharge to the fire main. The suction lift is not to exceed 20 feet (6 metres) with the ship in light draught. The fuel service tank for the engine is to have a capacity for at least 3 hours operation of the emergency pump. In addition sufficient fuel is to be available for at least 12 hours operation of this pump.

**Fire Hydrants, Hoses and Nozzles**

**506** In cargo ships the number of fire hoses to be provided, each complete with couplings and nozzles, is to be one for each 100 feet (30 metres) length of the ship and one spare, but in no case less than five in all for cargo ships of 1000 tons gross and over and three in all for smaller ships. These numbers do not include any hoses required in any engine or boiler room. If necessary the number of hoses is to be increased so as to ensure that hoses in sufficient number are available and accessible at all times, having regard to the type of the ship and the nature of the trade on which the ship is employed.

**507** In accommodation, service and machinery spaces, the number and position of hydrants are to be such as to comply with the requirements of F 210. In a cargo ship the arrangements are to be such that at least two jets of water can reach any part of any cargo space when empty.

In ships of 2000 tons gross and over a hydrant is to be provided in the shaft tunnel adjacent to the engine room watertight door.

**508** All hydrants in the machinery spaces of cargo ships with oil fired boilers or internal combustion type propelling machinery are to be fitted with hoses having in addition to the nozzles required in F 214 nozzles suitable for spraying water on oil, or alternatively, dual purpose nozzles.

**International Shore Connection**

**509** A cargo ship of 1000 tons gross and over is to be provided with at least one international shore connection, complying with F 215. Facilities are to be available enabling such a connection to be used on either side of the ship.

**Portable Fire Extinguishers in Accommodation and Service Spaces**

**510** A cargo ship is to be provided in accommodation, radio rooms and service spaces with a sufficient number of portable fire extinguishers to ensure that at least one extinguisher will be readily available for use in every compartment of the crew and passenger spaces to the Surveyors' satisfaction; in any case, their number is not to be less than five for ships of 1000 tons gross and over and not less than three in ships of under 1000 tons gross.

For galleys and for spaces containing domestic boilers one portable fire extinguisher suitable for dealing with oil fires or fires in electric cooking equipment is to be provided.

Where a sprinkler system is installed the arrangements will be specially considered.

**Fixed Fire Smothering Arrangements in Cargo Spaces**

**511** Cargo spaces of ships of 2000 tons gross and over are to be protected by a fixed fire smothering system using carbon dioxide, inert gas or steam. The arrangements are to comply with F 3.

**512** The cargo tanks of tankers of 500 tons gross and over are to be protected by a fixed fire smothering system using carbon dioxide, steam or froth. Installations discharging froth externally to the tanks may be accepted. The details of such installations are to be to the satisfaction of the Surveyors (for steam system *see* E 1119).

**513** The requirements of paragraph 511 may be waived for the cargo holds of any ship (other than the tanks of a tanker):—

(1) If they are provided with steel hatch covers having fireproof joints and effective means of closing all ventilators and other openings leading to the holds; or

(2) if the ship is constructed and intended solely for carrying such cargoes as ore, coal or grain; or

(3) where the ship is engaged on voyages of such short duration that it would be unreasonable to apply the requirement.

**Fire Detection in Cargo Spaces**

**514** A smoke or fire detection system is to be provided in each cargo space containing explosives and in adjacent cargo spaces.

**Fire Extinguishing Appliances in Boiler Rooms, etc.**

**515** In spaces where main or auxiliary oil-fired boilers are situated, or in spaces containing oil fuel units or settling tanks, a cargo ship is to be provided with any one of the following fixed fire extinguishing installations complying with F 3.

(1) A pressure water spraying system.

(2) A fire-smothering gas installation.

(3) A fixed froth installation supplemented, if necessary, by a fixed or mobile arrangement for pressure water or froth spraying to fight fire above the floor plates.

In each case if the engine and boiler rooms are not entirely separate, or if fuel oil can drain from the boiler room into the engine room bilges, the combined engine and boiler rooms are to be considered as one compartment.

**516** There are to be at least two approved portable extinguishers discharging froth or other approved medium suitable for extinguishing oil fires in each firing space in each boiler room and each space in which a part of the oil fuel installation is situated. In addition, there is to be at least one extinguisher of the same description with a capacity of 2 gallons (9 litres) for each burner, provided that the total capacity of the additional extinguisher or extinguishers need not exceed 10 gallons (45 litres) for any one boiler room.

**517** In each firing space there is to be a receptacle containing at least 10 cubic feet (0,28 metre$^3$) of sand, sawdust impregnated with soda, or other approved dry material and a scoop for distributing this material. Alternatively, an approved portable extinguisher may be substituted therefor.

**Fire Fighting Appliances in Spaces containing Internal Combustion Type Machinery**

**518** Where internal combustion engines or gas turbines are used, either (1) for main propulsion machinery, or (2) for auxiliary purposes associated with a total power not less than 1000 B.H.P., a cargo ship of 1000 tons gross and over is to be provided with the following arrangements A and B, and a cargo ship of under 1000 tons gross with arrangement B. For cargo ships of under 150 tons gross the provision of a 10 gallon (45 litre) extinguisher may be waived.

(A) There is to be one of the fixed arrangements 1, 2 or 3 required by paragraph 515.

(B) There is to be in each engine space one approved froth type extinguisher of not less than 10 gallons (45 litres) capacity or equivalent and also one approved portable froth extinguisher for each 1000 B.H.P. of the engines or part thereof; but the total number of portable extinguishers so supplied is not to be less than two and need not exceed six.

**Fire Fighting Arrangements in Spaces containing Steam Machinery**

**519** Provision is to be made for extinguishing lubricating oil fires in spaces which are separated from boiler rooms by watertight bulkheads when these spaces contain propulsion turbines or enclosed forced lubricated engines using superheated steam. Equipment not less effective than detailed in arrangement B of 518 is to be provided to the Surveyors' satisfaction.

**Fire Fighting Arrangements in Pump Rooms of Tankers**

**520** The cargo pump rooms in tankers of 500 tons gross and over are to be provided with a fixed, deck operated, fire extinguishing system using steam, carbon dioxide or other suitable medium.

In addition, two portable foam extinguishers or equivalent are to be provided, one at the pumps and one at the pump room entrance.

**Fireman's Outfits**

**521** A cargo ship is to carry at least one fireman's outfit complying with the requirements of F 335. Ships of 4000 tons gross and over are to carry two such outfits which are to be located at widely separated positions.

## Section 6

### REQUIREMENTS FOR SHIPS NOT FITTED WITH PROPELLING MACHINERY

**601** A power pump or hand pump is to be fitted having a suction from the sea and a discharge to deck for fire extinguishing purposes.

Where oil fuel is used for the generation of power, fire extinguishing appliances suitable for fighting oil fires are to be provided to the satisfaction of the Surveyors.

# PART 2

# FIRE PROTECTION IN PASSENGER, CARGO AND OTHER SHIPS

## Section 7

### GENERAL

**701** Except where otherwise stated, the requirements of Part 2 of this Chapter apply to passenger ships carrying more than 36 passengers, and cargo ships of 4000 tons gross and over, to be classed for unrestricted service.

**702** While the requirements satisfy the regulations of the International Convention for the Safety of Life at Sea, 1960, attention should also be given to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered. Compliance with these statutory requirements may be accepted as meeting the requirements of this Chapter.

**703** Consideration will be given to special cases where the arrangements are equivalent to those required by these Rules. Consideration will also be given to fire protection arrangements in ships to be classed for restricted or special services.

**704** Plans showing the proposed arrangements are to be submitted for approval.

#### Materials

**705** The hull, superstructures, bulkheads, decks and deckhouses are to be of steel or other material which, by itself or due to insulation provided, has structural and fire integrity properties equivalent to steel. In cargo ships the use of other suitable material will be specially considered.

**706** Pipes conveying oil or combustible liquids are to be of approved material having regard to the fire risk. Materials readily rendered ineffective by heat are not to be used for overboard scuppers, sanitary discharges and other outlets which are close to the water line and where the failure of the material in the event of fire would give rise to dangers of flooding.

## Section 8

### REQUIREMENTS FOR PASSENGER SHIPS CARRYING MORE THAN 36 PASSENGERS

#### Main Vertical Fire Zones and Fire Divisions

**801** The hull, superstructures and deckhouses are to be sub-divided into main vertical fire zones, the mean length of which on any one deck does not in general exceed 131 feet (40 metres), by "A" Class fire-resisting divisions as defined in the Safety Convention. Steps and recesses are to be kept to a minimum and are to be of "A" Class divisions.

As far as practicable, the bulkheads forming the boundaries of the main vertical fire zones above the bulkhead deck are to be in line with watertight sub-division bulkheads situated immediately below. Such bulkheads are to extend from deck to deck and to the shell or other boundaries.

#### Openings in "A" Class Fire-Resisting Divisions

**802** Where "A" Class divisions are pierced for electric cables, pipes, trunks, ducts, girders, beams, etc., arrangements are to be made to ensure that the fire resistance is not impaired.

**803** Dampers are to be fitted in ventilation trunks and ducts passing through main vertical fire zone bulkheads and are to have local control capable of operation from both sides of the bulkhead. The operating positions are to be readily accessible and marked in red lettering. Indicators are to be fitted to show whether the dampers are open or shut.

**804** Except for tonnage openings and hatches to cargo, store and baggage spaces, all openings are to be provided with permanently attached means of closing which are to be at least as effective for resisting fires as the divisions in which they are fitted. Where "A" Class divisions are pierced by tonnage openings the means of closure are to be steel plates.

**805** Doors and door frames in "A" Class divisions, with the means of securing them closed, are to provide resistance to fire and to the passage of smoke and flame equivalent to that of the bulkheads in which the doors are situated. Watertight doors need not be insulated.

Each door is to be capable of being opened from each side of the bulkhead by one person only. Fire doors in main vertical zone bulkheads other than watertight doors, are to be of the self-closing type with simple and easy means of release from the open position. These doors are to be of approved type, and the self-closing mechanism is to be capable of closing the door against an inclination of $3\frac{1}{2}$ degrees opposing closure.

**Bulkheads within Main Vertical Fire Zones**

**806** In ships in which Safety Convention Method I or III fire protection arrangement is adopted, and in which an automatic sprinkler system is not to be fitted, the enclosure bulkheads within accommodation spaces, other than those required to be "A" Class fire-resisting divisions, are to be constructed of "B" Class fire-retarding divisions as defined in the Safety Convention. The arrangement of fire-retarding divisions will be specially considered in relation to the method of fire protection adopted.

Accommodation spaces are halls, dining rooms, lounges and similar permanently enclosed spaces, corridors, lavatories, cabins, offices, crew's quarters, barber shops, isolated pantries and lockers and similar spaces.

**Separation of Accommodation Spaces from Machinery, Cargo and Service Spaces**

**807** The boundary bulkheads and decks separating accommodation spaces from machinery, cargo and service spaces are to be "A" Class fire-resisting divisions, the insulating value of which will be specially considered having regard to the nature of the adjacent spaces.

Machinery spaces include all spaces used for propelling, auxiliary or refrigerating machinery, boilers, pumps, workshops, generators, steering gear, ventilation and air conditioning machinery, oil filling stations and similar spaces and trunks to such spaces.

Service spaces are galleys, main pantries, stores, (except isolated pantries and lockers), mail and specie rooms and similar spaces and trunks to such spaces.

Primary deck coverings within accommodation spaces, control stations, stairways and corridors are to be of approved material which will not readily ignite.

**Protection of Stairways in Accommodation and Service Spaces**

**808** Stairways in accommodation and service spaces are to be of steel frame or other approved equivalent construction and are to be within enclosures formed of "A" Class divisions with positive means of closure at all openings from the lowest accommodation deck at least to a level which is directly accessible to the open deck, except that:—

(1) a stairway connecting only two decks need not be enclosed, provided the integrity of the deck is maintained by proper bulkheads or doors at one level;

(2) stairways may be fitted in the open in a public space, provided they lie wholly within such public space.

Stairway enclosures are to have direct communication with the corridors and are to be of sufficient area to prevent congestion having in view the number of persons likely to use them in an emergency, and are to contain as little accommodation, or other enclosed space in which a fire may originate, as practicable.

The insulation value of stairway enclosure bulkheads will be specially considered having regard to the nature of the adjacent spaces. The means for closure at openings in stairway enclosures are to be at least as effective for resisting fire as the bulkheads in which they are fitted. Doors other than watertight doors are to be of the self-closing type, as required for the main vertical fire zone bulkheads in accordance with 805.

The construction and protection of auxiliary stairways which do not form part of the general means of escape will be specially considered.

**Protection of Lift Trunks, Light and Air Trunks, Control Stations and Storerooms, etc.**

**809** Passenger and service lift trunks, vertical trunks for light and air to passenger spaces, etc., are to be of "A" Class fire-resisting divisions. Doors are to be of steel or other equivalent material and when closed are to provide fire resistance at least as effective as the trunks in which they are fitted.

Lift trunks are to be so fitted as to prevent the passage of smoke and flame from one 'tween deck to another and are to be provided with means of closing so as to permit of draught and smoke control. Insulation need not be fitted to lift trunks which are within stairway enclosures.

Where a trunk for light and air communicates with more than one 'tween deck space and where smoke and flame are likely to be conducted from one 'tween deck to another, smoke shutters, suitably placed, are to be fitted so that each space can be isolated in case of fire.

Any other trunk (e.g. for electric cables) are to be so constructed as not to afford passage for fire from one 'tween deck or compartment to another.

**810** Control stations are to be separated from the remainder of the ship by "A" Class bulkheads and decks.

Control stations are those spaces in which radio, main navigating or central fire-recording equipment or the emergency generator is located.

**811** The boundary bulkheads of baggage rooms, mail rooms, store rooms, paint and lamp lockers, galleys and similar spaces are to be of "A" Class divisions. Spaces containing highly inflammable stores are to be so situated as to minimise the danger to passengers or crew in the event of fire.

**Superstructures**

**812** Superstructures of aluminium alloy will be specially considered in relation to the Safety Convention Method of fire protection adopted. Where the use of aluminium alloy is approved:—

(1) Adequate provision is to be made to ensure that, in the event of fire, arrangements for stowage, launching and embarkation into lifeboats and rafts remain as effective as if the superstructures were constructed of steel; and

(2) Crowns and casings of boiler and machinery spaces are to be of steel adequately insulated, and any openings therein suitably arranged and protected to prevent spread of fire.

(*See* F 323.)

**Windows and Sidescuttles**

**813** All windows and sidescuttles in bulkheads separating accommodation spaces and the weather are to be constructed with metal frames. The glass is to be retained by a metal glazing bead.

**814** In spaces containing main propulsion machinery, or oil-fired boilers, or auxiliary internal combustion type of machinery to total horse power of 1,000 or over, the following provisions are to be made:—

(1) skylights are to be capable of being closed from outside the space.

(2) skylights containing glass panels are to be fitted with external shutters of steel or other equivalent material permanently attached.

(3) any windows in casings of such spaces are to be of non-opening type and are to be fitted with external shutters of steel or other equivalent material permanently attached.

(4) in the windows and skylights referred to above, wire-reinforced glass is to be used.

**Ventilation Systems**

**815** The main inlets and outlets of all ventilation systems are to be capable of being closed from outside the space in the event of fire. In general, the ventilation fans are to be so disposed that the ducts reaching the various spaces remain within the same main vertical zone.

**816** All power ventilation, except cargo and machinery space ventilation, is to be fitted with master controls so that all fans may be stopped from either of two separate positions situated as far apart as practicable. Two master controls are to be provided for the power ventilation serving machinery spaces, one of which can be operated from a position outside the machinery space.

**817** Efficient insulation is to be provided for exhaust ducts from galley ranges where the ducts pass through accommodation spaces.

**Incombustible Materials**

**818** In ships in which Safety Convention Method I fire protection arrangement is adopted, and in which an automatic sprinkler system is not to be fitted, all linings, grounds, ceilings and insulations are to be of incombustible materials except in cargo spaces, mail rooms, baggage rooms, or refrigerated compartments of service spaces.

**819** In ships in which Safety Convention Method III fire protection arrangement is adopted, and in which an automatic sprinkler system is not to be fitted, the use of combustible materials of all kinds such as untreated wood, veneers, ceilings, curtains, cabins, etc., is to be reduced as far as practicable. In large public spaces, the grounds and supports to the linings and ceilings are to be of steel or equivalent material. All exposed surfaces in corridors or stairway enclosures and concealed or inaccessible spaces shall have low flame-spread characteristics.

**Automatic Sprinkler and Fire Alarm and Detection Systems**

**820** In ships in which Safety Convention Method II fire protection arrangement is adopted, and in which "B" Class fire-retarding divisions are not to be fitted within accommodation spaces, an automatic sprinkler and fire alarm system of an approved type, and complying with the requirements of F 317 to F 323, is to be installed and so arranged as to protect all enclosed spaces appropriated to the use or service of passengers or crew, except spaces which afford no substantial fire risk. (*See* M 507.)

**Automatic Fire Alarm and Fire Detection Systems**

**821** In ships in which Safety Convention Method III fire protection arrangement is adopted and in which an automatic sprinkler is not to be fitted, a fire-detecting system of an approved type is to be installed and so arranged as to detect the presence of fire in all enclosed spaces appropriated to the use or service of passengers or crew (except spaces which afford no substantial fire risk), and automatically to indicate at one or more points or stations where it could be most quickly observed by officers and crew, the presence or indication of fire and also its location.

**Miscellaneous Items**

**822** In all parts of the ship, paints, varnishes and similar preparations having a nitro-cellulose or other highly inflammable base are not to be used.

**823** In all parts of the ship, pipes penetrating "A" or "B" Class fire divisions are to be of approved material having regard to the temperature such fire divisions are required to withstand.

**824** In accommodation and service spaces, air spaces enclosed behind ceilings, panellings or linings are to be suitably sub-divided by close-fitting draught stops not more than 45 feet (13,7 metres) apart. In the vertical direction, such spaces including those behind linings of stairways, trunks, etc., are to be closed at each deck. Small holes are to be arranged in ceilings and bulkheading, so that it will be possible, without impairing the efficiency of the fire protection, for the fire patrols to detect any smoke originating in concealed and inaccessible spaces. The concealed surfaces of all bulkheads, linings, panellings, stairways, wood grounds, etc., in accommodation spaces are to have low flame-spread characteristics.

## Section 9

### PASSENGER SHIPS CARRYING NOT MORE THAN 36 PASSENGERS

**901** Passenger ships to be classed for unrestricted service and carrying more than 12 passengers but not more than 36 passengers need comply only with the fire protection requirements in F 705, F 706, F 801 to F 805, F 807, F 809 (first sub-paragraph), F 810 to F 815, F 822 and F 823.

**902** In addition, the following provisions shall apply:—

(i) All stairways and means of escape in accommodation and service spaces shall be of steel or other suitable material.

(ii) Power ventilation of machinery spaces shall be capable of being stopped from an easily accessible position outside the machinery spaces.

(iii) Except where all enclosure bulkheads in accommodation spaces conform with the requirements in F 806, an automatic fire detection system conforming with F 402 is to be provided.

*November, 1964*

## Section 10

### REQUIREMENTS FOR CARGO SHIPS OF OVER 4000 TONS GROSS

**Corridor Bulkheads in Accommodation**

**1001** The corridor bulkheads in accommodation spaces are to be of steel or constructed of "B" class panels. The requirements of "B" class panels are specified in Chapter II Regulation 35 of the Safety of Life at Sea Convention 1960.

**Protection of Interior Stairways, Lift Trunks, Galleys, Storerooms, etc.**

**1002** Interior stairways below the weather deck are to be of steel or other suitable material. Lift trunks within accommodation spaces shall be of steel or equivalent material. Bulkheads of galleys, paint stores, lamp rooms, boatswain's stores when adjacent to accommodation spaces and emergency generator rooms, if any, shall be of steel or equivalent material.

**Deck Coverings**

**1003** Deck coverings within accommodation spaces on the decks forming the crown of machinery and cargo spaces shall be of a type which will not readily ignite.

**Ventilation Systems**

**1004** Means shall be provided for stopping ventilating fans serving machinery and cargo spaces and for closing all doorways, ventilators, annular spaces around funnels and other openings to such spaces. These means shall be capable of being operated from outside such spaces in case of fire.

**Paints, etc.**

**1005** In accommodation and machinery spaces, paints, varnishes and similar preparations having a nitro-cellulose or other highly inflammable base are not to be used.

## Section 11

### REQUIREMENTS FOR CARGO SHIPS OF 500 TONS TO 4000 TONS GROSS

**1101** F 1004 is to be complied with.

# Chapter G

# CONDITIONS FOR SURVEY OF MACHINERY DURING CONSTRUCTION

## Section 1

**101** The materials used in the construction of the machinery, boilers and pressure vessels are to comply with the requirements of Chapter P. Materials, for which provision is not made in Chapter P, may be accepted after compliance with such tests as may be imposed, under specifications to be approved before the materials are ordered and construction is commenced.

The machinery, boilers and pressure vessels are to be inspected throughout, the boilers and pressure vessels tested by hydraulic pressure, and the machinery tested under full power working conditions by the Society's Engineer Surveyors, who will furnish a report to the Committee. If found satisfactory, the Committee will thereupon grant a certificate, and insert in the Register Book the appropriate class notation, as set forth in Chapter B, indicating that the machinery, boilers and pressure vessels are certified to have been in good order and safe working condition on that date.

**102** In cases of machinery which has been built under Special Survey, the distinguishing mark ✠ will be inserted before the appropriate class notation, as set forth in Chapter B.

**103** In ships built under Special Survey, the following items of machinery are also to be constructed under Special Survey:—

The main and auxiliary engines and boilers, superheaters, economisers (including press boilers and similar apparatus for floating whale-oil factories), steering engines, air receivers, air compressors, scavenge blowers and superchargers, oil fuel burning units, feed pumps, circulating and cooling water pumps, fire and bilge pumps, air pumps, ballast and oil fuel transfer pumps, water extraction pumps, lubricating oil pumps, fuel valve cooling pumps for oil engines, forced and induced draught fans, evaporators, distiller units, feed water heaters and pressure filters where the foregoing are intended for essential services and domestic boilers intended for working pressures exceeding 3,5 kg. per cm.$^2$ and having heating surfaces greater than 4,65 m$^2$.

Generators of 100 kW and over and motors of 100 h.p. and over intended for essential services.

Motors intended for coupling to fans for the circulation of air in refrigerated cargo spaces.

Electric slip couplings.

All electric propelling machinery including switchgear, control gear, cables, main and auxiliary generators, motor and exciters.

**104** In order to facilitate the inspection, plans in triplicate of the following items, together with the necessary particulars of the machinery, including the maximum power and the revolutions per minute, are to be submitted for consideration before the work is commenced:—

Boilers, superheaters and economisers.

Air receivers.

Crank, thrust, intermediate and screw shafting and screw shaft oil gland.

Clutch and reversing gear with methods of control and flexible coupling.

Reduction gearing. (*See also* H 503.)

Propeller (including spare propeller if supplied).

General arrangement of shafting showing relative positions of the main engines, flywheel, flexible coupling, gearing, thrust block, line shafting and bearings, stern tube, "A" bracket and propeller, whichever is applicable.

NOTES—Plans additional to the above should not be submitted unless the machinery is of a novel or special character affecting classification.

For Plans of Pumping and Piping required to be submitted, *see* E 101.

For Steam and Gas Turbines, *see* H 407.

For Welded Structures for Steam Reciprocating and Oil Engines, *see* H 902.

For Welded Pressure Vessels, *see* J 1806.

For Electrical Equipment and Electric Propelling Machinery, *see* M 102.

For Refrigerated Cargo Installations, *see* N 202.

**105** Where it is proposed to depart from the requirements of the Rules, the Committee will be prepared to give consideration to the circumstances of any special case.

**106** Any novelty in the construction of the machinery boilers or pressure vessels is to be reported to the Committee.

**107** The Surveyors are to examine and test the materials and workmanship from the commencement of the work until the final test of the machinery under full power working conditions; any defects, etc., are to be pointed out as early as possible.

Where strict adherence to normal survey procedure is impracticable as regards the material testing and hydraulic testing of small mass produced components, the Surveyors may adapt their survey to the system of production provided they can verify by sampling, check tests or other means that there is reasonable compliance with Rule requirements or equivalents. Before consideration is given to any special arrangements of this nature, it will be necessary for the Surveyors to visit the Firms' Works and satisfy themselves as to the procedure employed for the identification and quality control of materials and for inspecting and testing components during manufacture.

**108** The Surveyors may also, if requested, compare the work as it progresses with the requirements of the specification agreed upon by the parties concerned, and certify to the conditions thereof, as far as can be seen, being satisfactorily complied with.

*25th July, 1963*

**109** The machinery and boilers are to be securely fixed to the ship's structure to the satisfaction of the Surveyor. The bed plates, gear cases, thrust blocks and boiler fastenings are to be of robust construction.

**110** Refrigerating machinery using a toxic or inflammable refrigerant, such as ammonia, is to be installed in an efficiently ventilated compartment isolated from the propelling machinery spaces and shaft tunnels, and living quarters.

Methyl chloride refrigerant is not to be used.

Machinery using non-toxic and non inflammable refrigerants will not be subject to restriction on location in general, but proposals to install relatively large plants in propelling machinery spaces will require special consideration.

**111** Where it is proposed to apply centralised, bridge, or automatic controls to propulsion machinery and essential auxiliaries, refrigerated cargo installations, tanker pumping systems, etc., a description of the scheme is to be submitted in order that the effect of these arrangements on the safety of the ship and machinery and the preservation of the cargo may be assessed. Particulars are to be given of the spare gear to be carried for machinery and control gear and whether maintenance is to be by repair or replacement.

Controls essential for the safe operation of the ship and preservation of the cargo are to be proved at the sea trials to the Surveyor's satisfaction.

**Cross-references**

**112** For conditions relating to the survey during construction of Electrical Equipment, Electrical Propelling Machinery and Refrigerating Machinery and Appliances, *see* M 1, M 17 and N 1 respectively.

# Chapter H

# MAIN AND AUXILIARY ENGINES AND GEARING

## Section 1

### GENERAL REQUIREMENTS

#### Materials

**101** Shafts, webs of built crankshafts and other important machinery parts are to be made and tested in accordance with the requirements of Chapter P or, in special cases, with an approved specification, under the supervision of the Surveyors.

**102** Where it is proposed to use non-ferrous metal for shafting, details of the specification and method of manufacture are to be submitted for consideration.

#### Inspection

**103** The surfaces of shafting and other important machinery parts are to be examined when finish machined and, if required by the Surveyors, also in the rough machined condition.

#### Alignment Gauges

**104** All main and auxiliary oil engines exceeding 300 b.h.p. and all main steam reciprocating engines are to be provided with alignment gauges which may be either a bridge gauge or a micrometer clock gauge for use between the crank webs.

Only one micrometer clock gauge, suitable for all the engines, need be supplied for each ship.

Main and auxiliary steam turbines are to be provided with gauges of an approved type for testing the alignment of the rotor, pinion and gear wheel shafts.

Wear down gauges and turbine alignment gauges should be adjusted in the presence of the Surveyor.

#### Definitions

**105** Where horse power appears in this Chapter it is to be taken as 76 m. kg. per second.

#### Cross-References

**106** For means of escape from machinery spaces and communication between bridge and engine room, *see* D 2216 and D 2217.

## Section 2

### STEAM RECIPROCATING ENGINES

#### Dimensions of Shafts

**201** The crank, intermediate and other shafts, if of ordinary mild steel having a tensile breaking strength of 44–52 kg. per mm.$^2$ are to be of not less diameters than those given by the following formulæ.

Where shafts are proposed to be made of high tensile steel, their sizes, together with the material specification, should be submitted for special consideration.

#### Torsional Vibrations

**202** The formulæ do not, however, take into consideration the possibility of severe torsional vibration stresses arising in the shafting. Where engines have cylinders of uniform diameter and in other types of engines where experience indicates that serious critical speeds might occur within or near the range of working speeds, calculations of the torsional vibration characteristics, including 1-node natural frequency tables, for the complete shafting system, are to be submitted for consideration, together with plans of all shafting and of the propeller.

Similar calculations are to be submitted for the system including the spare propeller, if supplied, where its design differs from that of the working propeller.

These calculations are not required to be submitted for engines other than these special cases; they may, however, be submitted voluntarily, if desired.

The Committee will accept intermediate shafts with a diameter 5 per cent less than required by the Rule formulæ, in all cases where calculations confirm that the shafting systems are free from excessive vibration stress or would be satisfactory with a barred speed range.

This 5 per cent reduction in diameter will be limited to the intermediate shafts only and will not be applicable to the sizes of couplings and their bolts.

Where serious critical speeds are found by calculation to occur within the range of working speeds, the Committee may require torsiograph records to be taken from the machinery, for the purpose of verifying the calculations

and may impose a restriction on continuous running at speeds where the stresses are considered to be excessive.

### Intermediate Shaft

**203** The diameter of the intermediate shaft is not to be less than that given by the following formula:—

Diameter of intermediate shaft, in millimetres=

$$\sqrt[3]{\frac{D^2 \times S \times WP \times 14{,}22}{C\left(\frac{D^2}{H^2} + 2\right)}}$$

where WP=working pressure at the boiler outlet, in kg. per cm$^2$.

NOTE.—The working pressure at the boiler outlet is the pressure as controlled by boiler or superheater safety valves and as defined in E 512.

D = diameter of the low pressure cylinder, in millimetres, or the equivalent diameter where two or more low pressure cylinders are fitted,

H = diameter of the high pressure cylinder, in millimetres,

S = length of stroke, in millimetres,

C is a coefficient given in the following Table:—

| Compound, triple or quadruple expansion reciprocating engines | Values of C |
|---|---|
| 2 cranks at 90° ... ... | 1900 |
| 2 cranks at 180° ... ... | 1350 |
| 3 cranks at 120° ... ... | 2150 |
| 4 cranks balanced... ... | 2150 |
| 4 cranks at 90° ... ... | 2100 |

NOTE:—The rule diameter of the intermediate shaft may be reduced by 3,5 per cent for ships classed exclusively for smooth water service and by 1,75 per cent for ships classed exclusively for service on the Great Lakes.

For the diameter of the intermediate shafting of steam reciprocating engines combined with exhaust steam turbines, *see* H 303.

### Crank Shaft

**204** The diameter of the crank shaft is not to be less than 1,05 times that required for the intermediate shaft, as determined by 203.

### Crank Webs of Solid Forged Shafts

**205** In solid forged shafts the breadth of the webs should not be less than 1,33 times and the thickness not less than 0,56 times the diameter required for the crank shaft or, if these proportions are departed from, the webs are to be of equivalent strength.

### Crank Webs of Built Shafts

**206** The dimensions of the crank webs of built shafts should not be less than those given by the following formulæ:—

$$h = 0{,}625 \times d$$

$$t = \sqrt{\frac{0{,}12 \times d^3}{h}}$$

where h = thickness of the web, measured parallel to the axis, in millimetres,

t = thickness of metal around the eyeholes, measured radially, in millimetres,

d = diameter required for the crank shaft, in millimetres.

If these proportions are departed from, the webs are to be of equivalent strength.

**207** Reference marks are to be provided on the outer junction of the crank webs with the journals and crank pins.

### Shrinkage Allowance

**208** Crank webs are to be securely shrunk on the journals and crank pins. If dowels are not fitted at the junction of the journals and webs, the yield point of the material of the webs is to be not less than 22 kg. per mm.$^2$, and the shrinkage allowance is to be between $\frac{1}{550}$ and $\frac{1}{700}$ of the diameter of the shaft.

### Fillets and Oil Holes

**209** Fillets at the junctions of crank webs with crank pins or journals, where these are formed as solid forgings or castings, are to be machined to a smooth radius.

Oil holes at the surfaces of crank pins and journals are to be rounded to an even contour with a smooth finish.

### Thrust Shaft

**210** The diameter at the collars of the thrust shaft transmitting torque is not to be less than 1,05 times that required for the intermediate shaft as determined by 203. Outside the collars the diameter may be tapered down to that required for the intermediate shaft.

### Tube Shaft

**211** The diameter of the tube shaft which passes through the stern tube but does not carry the propeller, is not to be less than 1,05 times that required for the intermediate shaft as determined by 203, and any part of the shaft within the tube which may be exposed to sea water is not to be less than 1,075 times the diameter required for the intermediate shaft as determined by 203.

### Screw Shaft

**212** The diameter of the screw shaft carrying the propeller is not to be less than that given by the following formula:—

$$\text{Diameter of screw shaft, in millimetres} = d + \frac{P}{C}$$

where $d$ = diameter required for the intermediate shaft, in millimetres, as determined by 203,

$P$ = diameter of the propeller, in millimetres,

$C$ = 144 when the shaft is fitted with a continuous liner,
100 when the shaft is not fitted with a continuous liner.

**213** Screw shafts which run in stern tubes may have the end forward of the stern gland tapered down to a diameter, at the coupling flange, of 1,05 times that required for the intermediate shaft.

### Hollow Shafts

**214** Where the thrust, intermediate, tube and screw shafts have central holes, the dimensions of the shafts as determined by the foregoing formulæ need not be increased, provided the diameter of the central hole in a shaft does not exceed one-third of the shaft diameter.

### Bronze Liners on Shafts

**215** The thickness of liners fitted on screw shafts or on tube shafts, in way of the bushes, is not to be less, when new, than that given by the following formula:—

$$t = \frac{d + 235}{32}$$

where $t$ = thickness of the liner, in millimetres,

$d$ = diameter required for the screw or tube shaft under the liner, in millimetres.

**216** The thickness of a continuous liner between the bushes is not to be less than 0,75 t.

**217** Continuous liners should be cast in one piece or, if made of two or more lengths, the junctions of the separate pieces are to be made by fusion through the whole thickness of the liner.

**218** Liners are to be carefully shrunk on, or forced on to the shafts by hydraulic pressure. Pins are not to be used to secure the liners.

**219** If the liner does not fit tightly between the bearings in the stern tube, the space between the shaft and the liner is to be charged or forced with a plastic material insoluble in water and non-corrosive.

**220** Effective means are to be provided for preventing water from having access to the shaft at the part between the after end of the liner and the propeller boss.

### Stern Bush

**221** The length of the bearing in the stern bush next to and supporting the propeller is not to be less than four times the diameter required by rule for the screw shaft under the liner.

### Coupling Bolts

**222** With coupling bolts of ordinary mild steel having a minimum tensile strength of 44 kg. per mm.$^2$, the diameter of the bolts at the joining faces of the couplings is not to be less than that given by the following formula:—

$$\text{Diameter of coupling bolts, in millimetres} = \sqrt{\frac{d^3}{3{,}5 \times n \times r}}$$

where $d$ = diameter required for the intermediate shaft, in millimetres, as determined by 203, H 303 or H 304, whichever is applicable,

$n$ = number of bolts in the coupling,

$r$ = radius of the pitch circle of the bolts, in millimetres.

### Couplings

**223** The thickness of the coupling flanges at the pitch circle of the bolt holes is not to be less than the diameter of the coupling bolts at the face of the coupling as determined by 222. The thickness of the screw shaft coupling flange is not to be less than 0,25 of the diameter required for the intermediate shaft as determined by 203, H 303 or H 304, whichever is applicable.

**224** The fillet radii at the base of flanges should not be less than 0,125 of the diameter of the shaft.

**225** Where couplings are separate from the shafts provision is to be made to resist the astern pull.

### Bronze Propellers

**226** Where bronze is used for propellers or propeller blades, it is to comply with the requirements of P 10.

## Section 3

### TURBINES AND PROPELLING MOTORS

#### Dimensions of Shafts

**301** The intermediate and other shafts, if of ordinary mild steel having a tensile breaking strength of 44-52 kg. per mm.$^2$, are to be of not less diameters than those given by the following formulæ.

Where shafts are proposed to be made of high tensile steel, their sizes, together with the material specification, should be submitted for special consideration.

#### Torsional Vibrations

**302** The formulæ do not, however, take into consideration the possibility of torsional vibration arising in the shafting and gearing.

With turbines or electric motors geared to the shafting and situated aft, calculations of the torsional vibration characteristics for the dynamic system formed by the turbine, motor, gearing, line shafting and propeller are to be submitted for consideration, together with plans of all shafting and propeller and details of power developed by individual turbines throughout the speed range.

Similar calculations are to be submitted for the system including the spare propeller, if supplied, where its design differs from that of the working propeller.

Where serious critical speeds are found by calculation to occur within the range of working speeds the Committee may require torsiograph records to be taken from the machinery for the purpose of verifying the calculations and may impose a restriction on continuous running at speeds where the vibration torques, as evidenced by tooth separation and gear hammer, are considered to be excessive.

#### Steam Reciprocating Engines combined with Exhaust Steam Turbines

**303** Where steam reciprocating engines are combined with exhaust steam turbines by means of mechanical gearing the diameter of the intermediate shaft is not to be less than that given by the following formula:—

$$\left.\begin{array}{l}\text{Diameter of intermediate}\\ \text{shaft, in millimetres}\end{array}\right\} d = 89\sqrt[3]{\frac{SHP}{R}}$$

where SHP = maximum combined shaft horse power at the intermediate shaft,

R = revolutions per minute at maximum power.

NOTE: The s.h.p. of a reciprocating engine may be taken as 90 per cent of the indicated horse power.

The diameter of the straight shafting should in no case be less than required for the reciprocating engine when working without a turbine.

The sizes of thrust, tube and screw shafts are to be determined by H 210 to H 213.

#### Turbines and Electric Propelling Motors

**304** The diameter of the intermediate shaft is not to be less than that given by the following formula:—

$$\left.\begin{array}{l}\text{Diameter of intermediate}\\ \text{shaft, in millimetres}\end{array}\right\} d = 89\sqrt[3]{\frac{SHP}{R}}$$

where SHP = maximum designed shaft horse power,

R = revolutions per minute at maximum power.

NOTE: The rule diameter of the intermediate shaft as determined by 303 or 304 may be reduced by 3,5 per cent for ships classed exclusively for smooth water service and by 1,75 per cent for ships classed exclusively for service on the Great Lakes.

#### Wheel Shafts of Geared Turbines

**305** Where there are two pinions geared into the wheel, opposite, or nearly opposite, to one another, the diameter of the wheel shaft is not to be less than 1,1 times that required for the intermediate shaft.

**306** Where there is only one pinion geared into the wheel, or where there are two pinions which are set to subtend an angle at the centre of the shaft of less than 120 degrees, the diameter of the shaft at the wheel and the adjacent journals is not to be less than 1,16 times that required for the intermediate shaft. Abaft the journals the shaft may be gradually tapered down to the diameter required for the intermediate shaft.

#### Cross-References

**307** For turbines and electric motors, the requirements for thrust, tube and screw shafts and associated items are to be in accordance with H 604 and H 613 to H 625.

## Section 4

### GENERAL REQUIREMENTS FOR STEAM RECIPROCATING ENGINES AND STEAM AND GAS TURBINES

#### STEAM RECIPROCATING ENGINES

**401** Explosion relief devices are to be fitted to the crank cases of enclosed forced lubricated steam reciprocating engines where the crank case volume is 0,57 m.$^3$ and over. The arrangement and sizes of the relief devices

are to comply with the requirements of H 713 to H 716 where applicable. There is also to be compliance with H 718.

**402** Auxiliary steam engines intended for driving electric generators are to be fitted with governors which, with fixed setting, are to control the speed within the following limits:—

10 per cent momentary variation and 6 per cent permanent variation in speed when full load is suddenly taken off or put on, but for any A.C. installation the permanent speed variations of the machines intended for parallel operation are to be equal within a tolerance of $\pm 0{,}5$ per cent.

### Hydraulic Tests

**403** The cylinders of steam reciprocating engines are to be tested by hydraulic pressure as follows:—

COMPOUND EXPANSION ENGINES:

| | |
|---|---|
| H.P. Cylinder ... ... | WP × 1,5 |
| L.P. Cylinder ... ... | 2 kg. per cm.$^2$ |

TRIPLE EXPANSION ENGINES:

| | |
|---|---|
| H.P. Cylinder ... ... | WP × 1,5 |
| I.P. Cylinder ... ... | WP × 0,5 |
| L.P. Cylinder ... ... | 2 kg. per cm.$^2$ |

QUADRUPLE EXPANSION ENGINES:

| | |
|---|---|
| H.P. Cylinder ... ... | WP × 1,5 |
| First I.P. Cylinder ... | WP × 0,6 |
| Second I.P. Cylinder ... | WP × 0,4 |
| L.P. Cylinder ... ... | 2 kg. per cm.$^2$ |

Where WP is the boiler working pressure in kg. per cm.$^2$

### Astern Power

**404** Ships are to have sufficient power for going astern to secure proper control of the ship in all normal circumstances.

### Trials

**405** The sea trials are to be of sufficient duration to prove the machinery under power and normal manœuvring conditions.

In the case of passenger ships, the ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, under normal manœuvring conditions, and so bring the ship to rest from maximum ahead service speed is to be demonstrated at the sea trials.

All trials are to be to the Surveyor's satisfaction.

## STEAM AND GAS TURBINES

### General

**406** The following requirements are applicable, except where otherwise stated, to steam and gas turbines for main propulsion and for essential auxiliary services where powers exceed 150 s.h.p. Features of gas turbine machinery which are not included in this section will be specially considered.

### Plans

**407** The following plans are to be submitted for consideration, together with particulars of materials and of maximum designed powers and speeds. The pressures and temperatures applicable at full power and under the emergency conditions of 443 are to be stated or indicated on the plans.

1. General arrangement.
2. Sectional assembly.
3. Rotors and couplings.
4. Cylinders.
5. Combustion chamber and heat exchangers.

For main steam turbines plans 1, 2 and 3 are required in all cases and 4 when the cylinders are of welded construction. In general for auxiliary steam turbines no plans need be submitted. For main and auxiliary gas turbines plans 1 to 5 are required.

Where rotors and cylinders are of welded construction plans showing details of the welded joints are also to be submitted for consideration.

### Materials

**408** Plates, forgings, castings and pipes used in the construction of turbine cylinders, rotors, couplings and other important components are to be of approved composition and be tested in accordance with the relevant requirements of Chapter P, or of an approved Specification.

**409** In the selection of materials for high temperature applications in advanced steam and gas turbines consideration is to be given to their creep strength, corrosion resistance and scaling properties at working temperatures to ensure satisfactory performance and long life under service conditions.

### Stability Testing of Turbine Rotors

**410** All solid forged H.P. steam and gas turbine rotors intended for main propulsion service where the inlet steam or gas temperature exceeds 750° F. (400° C.) are to be subjected to at least one thermal stability test. This requirement is also applicable to rotors fabricated as in 426. The test may be carried out at the Forge or Turbine Builders'

Works (*a*) after heat treatment and rough machining of the forging, or (*b*) after final machining, or (*c*) after final machining and blading of the rotor. The stabilising test temperature is to be not less than 50° F. (28° C.) above the maximum steam or gas temperature to which the rotor will be exposed and not more than the tempering temperature of the rotor material. For details of a recommended test procedure and limits of acceptance *see* P 6. Other test procedures may be adopted if approved.

Where main turbine rotors are subjected to thermal stability tests at both Forge and Turbine Builders' Works the foregoing requirements are applicable to both tests. It is not required that auxiliary turbine rotors be tested for thermal stability, but if such tests are carried out, the requirements for main turbine rotors will be generally applicable.

### Design and Construction

**411** In the design and arrangement of turbine machinery adequate provision is to be made for the relative thermal expansion of the various turbine parts, and special attention is to be given to minimising casing and rotor distortion under all operating conditions.

**412** Indicators for determining the axial position of rotors relative to their casings and for showing the longitudinal expansion of casings at the sliding feet, if fitted, are to be provided for main turbines. The latter indicators should be fitted at both sides and be readily visible.

**413** Pipes and ducts connected to turbine casings are to be so designed that no excessive thrust loads or moments are applied by them to the turbines. Gratings and any fittings in way of sliding feet or flexible-plate supports are to be so arranged that casing expansion is not restricted. Where main turbine seatings incorporating a tank structure are proposed, consideration is to be given to the temperature variation of the tank in service to ensure that turbine alignment will not be adversely affected.

**414** In arranging the gland-sealing system of steam turbines the pipes are to be made self-draining and every precaution is to be taken against the possibility of condensed steam entering the glands and turbines. The steam supply to the gland-sealing system is to be fitted with an effective drain trap. In the air ejector re-circulating water system the connection to the condenser is to be so located that water cannot impinge on the L.P. rotor or casing.

**415** The turning gear for all propulsion turbines is to be power-driven and if electric is to be continuously rated.

**416** Turbine rotors are to be made of forged material with a tensile strength for low alloy steel not exceeding 91 kg. per mm.$^2$ for solid rotors and 107 kg. per mm.$^2$ for the discs and spindles of built rotors. Where carbon steel forgings are adopted the tensile strength is not to exceed 71 kg. per mm.$^2$ (*See* P 6.)

**417** Discs of built rotors fitted by shrinking are to be secured with keys, dowels or other approved means in main turbines.

**418** Smooth fillets are to be provided at abrupt changes of section of rotors, spindles, discs, blade roots and tenons. The rivet holes in blade shrouds are to be rounded and radiused on top and bottom surfaces and tenons to be radiused at junction with blade tips. Balancing holes in discs are to be well rounded and polished.

**419** Surveyors are to be satisfied as to the workmanship and riveting of blades to shroud bands and that the blade tenons are free from cracks, particularly with high tensile blade material. Test samples are to be sectioned and examined and pull-off tests made if considered necessary by the Surveyors.

**420** All rotors, as finished-bladed and complete with half coupling, are to be dynamically balanced in a machine of appropriate sensitivity for the size of rotor, to the Surveyors' satisfaction.

**421** Turbine cylinder castings are to be of approved material suitable for the working metal temperature. Ordinary cast iron is not to be used for temperatures exceeding 500° F. (260° C.) The castings are to be stress relief heat treated after rough machining, except that this requirement may be waived for small castings at the Surveyors' discretion. The stress relieving temperature is not to exceed the tempering temperature. (*See* P 5 for Steel Castings.)

**422** Turbine bearings are to be so disposed and supported that lubrication is not adversely affected by heat flow from adjacent hot parts of the turbine. Effective means are to be provided for intercepting oil leakage and preventing any oil from reaching high temperature glands and casings. Drainage openings from oil baffles are to be amply large. (*See* H 104 for alignment gauges.)

### Welded Components

**423** Turbine rotors, cylinders and associated components fabricated by means of welding will be considered for acceptance if constructed by firms whose works are properly equipped to undertake welding of equivalent standards, for rotor and cylinders respectively, to those

required by the Rules for Class 1 and 2 Welded Pressure Vessels. (*See* J 19 and J 20.)

**424** Welded combustion chambers, heat exchangers, gas collector vessels, pressure ducting and piping are to comply with the relevant sections of Chapters J (pressure vessels) and E (pipes).

**425** Materials used in the construction of turbine rotors, cylinders, diaphragms, condensers, etc., are to be of welding quality.

**426** Where it is proposed to construct rotors from two or more forged components joined by welding, full details of the chemical composition, mechanical properties and heat treatment of the materials, together with electrode particulars, an outline of the welding procedure, method of fabrication and heat treatment are to be submitted for consideration.

**427** Joints in rotors and major joints in cylinders are to be designed as full-strength welds and for complete fusion of the joint.

**428** In the first instance and before work is commenced the Surveyors are to be satisfied that the desired quality of welding is attainable with the proposed welding procedure, and for this purpose test specimens representative of the welded joints are to be provided for radiographic examination and mechanical tests. For cylinders the mechanical tests of butt joints are to include tensile, bend and nicked bend tests as detailed in J 20. For diaphragms, nozzle plates etc., representative samples are to be sectioned and macro-etched. For rotors the mechanical tests are to include tensile (all weld metal), tensile (joint), bend (transverse), bend (longitudinal) and macro tests as detailed in J 19 or such other tests as may be approved. In subsequent production, check mechanical tests are to be carried out at the Surveyors' discretion if the quality of the welding is found to be unsatisfactory.

**429** Adequate preheating is to be employed for mild steel cylinders and components where the metal thickness exceeds 44 mm. and for all low alloy steel cylinders and components and for any part where necessitated by joint restraint.

**430** Stress relief heat treatment is to be applied to all cylinders and associated components on completion of the welding of all joints and attached structures. (*See* J 1925 for details of stress relief procedure, temperature and duration.)

**431** The heat treatment of welded rotors is to be carried out as approved.

**432** Routine examinations by non-destructive methods are to be made of all cylinders and rotors on completion of heat treatment as follows:—

CYLINDERS.—Major stressed joints in pressure shells are to be radiographed if practicable; other joints such as nozzle plate and branch pipe connections and diaphragm joints are to be examined by crack detection methods.

ROTORS.—All joints are to be examined by radiography or other approved methods and by magnetic crack detection methods.

**433** The whole of the welding work is to be to the satisfaction of the Surveyors.

### Governors and other Safety Devices

**434** An emergency overspeed governor is to be provided for main and auxiliary steam turbines so as to shut off the steam automatically and prevent the maximum designed speed being exceeded by more than 15 per cent.

**435** Where two or more propulsion turbines are coupled to the same main gear wheel and only one emergency governor is provided, it is to be fitted to the L.P. ahead turbine. Hand trip gear for shutting off the steam in emergency is to be provided at the manœuvring platform.

**436** Arrangements are to be made for the steam to the ahead propulsion turbines to be automatically shut off in the event of failure of the lubricating oil pressure. (*See* E 903 for emergency oil supply).

**437** Where a turbine installation incorporates a reverse gear, electric transmission or reversible propeller, a speed governor in addition to, or in combination with, the emergency governor is to be fitted and is to be capable of controlling the speed of the unloaded turbine without bringing the emergency governor into action.

**438** Auxiliary turbines intended for driving electric generators are to be fitted with speed governors which, with fixed setting, are to control the speed within the following limits:—

10 per cent momentary variation and 6 per cent permanent variation in speed when full load is suddenly taken off or put on, but for any A.C. installation the permanent speed variations of the machines intended for parallel operation are to be equal within a tolerance of $\pm$ 0,5 per cent.

**439** Sentinel relief valves are to be provided at the exhaust ends or other approved positions of all main steam turbines and the valve discharge outlets are to be visible and

suitably guarded if necessary. Where a low vacuum cut-out valve is provided the sentinel relief valve at the L.P. exhaust may be omitted.

**440** Non-return valves or other means, which will prevent steam and water returning to the turbines, are to be fitted in bled steam connections.

**441** Efficient steam strainers are to be provided close to the inlets to ahead and astern high pressure turbines, or alternatively at the inlets to the manœuvring valves.

**442** The governing and other safety devices for propulsion gas turbine installations will be specially considered.

### Emergency Arrangements

**443** In single screw ships fitted with steam turbines the arrangements are to be such that steam can be led direct to the L.P. turbine and either the H.P. or I.P. turbine can exhaust direct to the condenser. Adequate arrangements and controls are to be provided for these emergency conditions so that the pressure and temperature of the steam will not exceed those which the turbines and condenser can safely withstand.

### Astern Power

**444** Sufficient astern power is to be provided to maintain control of the ship in all normal circumstances and in general for this purpose the astern turbine or turbines of steam and free-piston gas turbine installations are to be designed to develop when operating astern under transient conditions 80 per cent of the ahead torque at 50 per cent of the ahead revolutions and to maintain in free route astern 70 per cent of the ahead revolutions for a period of at least 30 minutes without undue heating of the ahead turbines and condenser. The aforementioned ahead torques and revolutions are to be based on the maximum ahead power for which the machinery is to be classed.

### Hydraulic Tests

**445** Manœuvring valves are to be tested to twice the working pressure. The nozzle boxes of impulse turbines are to be tested to 1,5 times the working pressure.

The cylinders of all turbines are to be tested to 1,5 times the working pressure in the casing or to 2 kg. per cm.$^2$, whichever is the greater.

For test purposes the cylinders may be sub-divided with temporary diaphragms for distribution of test pressures.

Condensers are to be tested in the steam space to 1 kg. per cm.$^2$. The water space is to be tested to the maximum pressure which the pump can develop with the discharge valve closed plus 0,7 kg. per cm.$^2$, with a minimum test pressure of 2 kg. per cm.$^2$. Where the operating conditions are not known, the test pressure is to be not less than 3,5 kg. per cm.$^2$. *See* E 802.

### Trials

**446** The sea trials are to be of sufficient duration to prove the machinery under power and normal manœuvring conditions. Where astern turbines or hydraulic reversing gear are fitted, astern running at 70 per cent of the full power ahead revolutions is to be demonstrated. The astern trial need only be of 15 minutes duration, but may be extended to 30 minutes at the Surveyors' discretion.

In the case of passenger ships, the ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, under normal manœuvring conditions, and so bring the ship to rest from maximum ahead service speed is to be demonstrated at the sea trials.

All trials are to be to the Surveyor's satisfaction.

### Cross-references

**447** Turbines intended for driving electric generators are to comply with the requirements of M 401 and M 402.

**448** Where auxiliaries are worked by electricity, the cables, motors, control gear and electrical spares are to comply with the requirements of Chapter M.

**449** The feed, bilge and general service pumps, steam and other pipes, cocks, sea connections, pumping arrangements and forced lubrication, are to comply with the requirements of Chapter E.

## Section 5

## REDUCTION GEARING FOR PROPELLING AND AUXILIARY MACHINERY

### General

**501** The following requirements, except where otherwise stated, are applicable to reduction gearing for main propelling purposes and for driving electric generators where the transmitted powers exceed 300 s.h.p. and 150 s.h.p. for propulsion and auxiliary drives respectively. In general, requirements are intended for helical type gears. Other types of gearing will be specially considered.

**502** The materials for pinions, pinion sleeves, wheel rims, flexible couplings and quill shafts are to be of

approved composition and mechanical properties and are to comply with the requirements of Chapter P. Manufacturers' certificates of test for materials may be accepted in cases where the transmitted power of gears is less than 150 s.h.p.

In the selection of materials for pinions and wheels consideration is to be given to their compatibility in operation; provision is also to be made for a hardness differential between pinion teeth and wheel teeth for which purpose the specified minimum tensile strength of the wheel rim material is to be not more than 85 per cent of that of the pinion. Normally, pinion materials are to have tensile strengths within the limits of 63 kg. per mm.$^2$ and 120 kg. per mm.$^2$, but consideration will be given to the acceptance of materials of greater tensile strength if it is demonstrated that these can be machined satisfactorily. These requirements are not applicable to case-hardened and surface-hardened elements which will be specially considered.

**503** Particulars of the gearing are to be submitted with the plans for all propulsion gears and for auxiliary gears where the transmitted power exceeds 150 s.h.p., as follows:—

Material specifications,
Shaft horse power and revolutions for each pinion,
Number of teeth in each gear,
Pitch circle diameters,
Helix angles,
Normal pitches of teeth,
Addenda,
Dedenda,
Face widths,
Pressure angles of teeth (normal or transverse),
Minimum backlash.

## Design

### Tooth Form

**504** The tooth profile in the transverse section is to be of involute shape and the roots of the teeth are to be formed with smooth fillets of radii, not less than 12 per cent of the normal pitch.

For propulsion gears the ends of the pinion and wheel teeth are to be cut back from the root at an angle of 45° to 60° to the pitch line in all cases where the ratio F/d exceeds 1,5.

where F = total axial length over pinion helices, less the gap, in mm.

d = pitch circle diameter of pinion, in mm.

The teeth of pinions and wheels of turbine gears are to be suitably tip-relieved in cases where any of the following conditions apply:—

(i) Normal pitch of teeth exceeds 20 mm.

(ii) Addendum of pinion teeth exceeds 65 per cent of total working depth of engagement.

(iii) Ratio of total working depth of engagement to normal pitch of teeth exceeds 0,75.

All sharp edges left on the tips and ends of pinion and wheel teeth after hobbing or finishing are to be removed.

### Tooth Loads

**505** For turbine gears of the through-hardened type, tooth loads are to be governed by the requirements of 506. Where it is desired to adopt higher K values than permitted by the requirements of 506, full design calculations for tooth strength and pinion deflection are to be submitted for consideration.

For oil engine gears of the through-hardened type tooth loads are normally to be governed by the requirements of 506. In cases of small gears or other special circumstances where it is desired to adopt higher loading than permitted by the formula, full particulars are to be submitted for consideration.

For turbine and oil engine gears of the surface hardened and ground or case-hardened and ground type the tooth loads will be specially considered.

**506** In order to limit the tooth surface stress the gear tooth load for maximum designed shaft horse power is not to exceed that given by the following formula:—

$$P = K \times d \times \frac{R}{(R + 1)}$$

where P = maximum permissible tooth load in kg. per cm. of overall face width less gap,

K = loading factor to be derived from the expression:—

$\frac{C\,(63 + S)}{225}$ but not to exceed $C \times 0{,}78$,

C = coefficient, having values obtainable from Table 1,

S = specified minimum tensile strength of pinion material, in kg. per mm.$^2$,

d = pitch circle diameter of pinion, in mm.,

R = gear ratio:— $\frac{\text{pinion speed}}{\text{gear wheel speed}}$

TABLE 1

| Service | Gear Type | Coefficient C | |
|---|---|---|---|
| Propulsion | Single Reduction ... ... | 1 | |
| Auxiliary | ,, ,, ... ... | 1,15 | |
| Propulsion | Double Reduction | Primary | Secondary |
| | Split Secondary ... ... | 1 | 0,85 |
| | ,, Primary ... ... | 1 | 0,85 |
| | Tandem ... ... ... | 1 | 0,85 |
| | ,, Articulated ... | 1,1 | 0,95 |
| | Dual Tandem ... ... | 0,9 | 0,85 |
| | ,, ,, Articulated ... | 1 | 0,95 |

NOTE.—By "Articulated Gear" is meant the connecting of primary and secondary gears by a quill shaft and coupling which will permit adequate flexibility.

For typical arrangements of double helical, double reduction gears *see* Fig. 1.

### Quill Shafts

**507** The diameter of the quill shaft is to be not less than given by the following formula:—

$$\text{diameter of quill shaft, in mm.} = 90 \sqrt[3]{\frac{SHP}{R} \times \frac{44}{S}}$$

where SHP = maximum designed power,

R = revolutions per minute at maximum designed power,

S = specified minimum tensile strength of the material, in kg. per mm.$^2$, which is not to be less than 44 kg. per mm.$^2$

## CONSTRUCTION

### Gear Wheels and Pinions

**508** Where wheels are of cast construction any radial slots in the periphery are to be fitted with permanent chocks before shrinking of the rim.

When bolts are used to secure side plates to rim and hub, the bolts are to be a tight fit in the holes and not to be locked by welding.

When welding is employed in the construction of wheels, the welding procedure is to be approved in the first instance by the Surveyors before work is commenced. For this purpose, test specimens representative of the welded joints used in the construction of the wheel are to be provided for examination and mechanical test. Sections are also to be taken from the test joints at positions selected by the Surveyors, and are to be macro-etched to verify that the welds are sound. Wheels are to be stress relieved after welding. All welds are to have a smooth surface and even contour and are to be proved by magnetic crack detection methods.

### Gear Cases

**509** Gear cases are to be of rigid design and if welding is employed in their construction they are to be stress relieved on completion. Provision is to be made by the gear manufacturers for verifying by trammels or other means during installation of the gear case on board ship that it is free from distortion when chocked and secured to its seating.

### Balance of Gear Pinions and Wheels

**510** All primary pinions over 300 mm. diameter, complete with couplings, are to be dynamically balanced. All primary wheels, including those with secondary pinions, also main wheels are to be statically balanced.

### Accuracy of Gear Cutting and Alignment

**511** Turbine gearing is to be cut only on machines which are maintained at a high standard of accuracy. When large gears are designed with loading factors exceeding K = 0,56 any hobbing machines used in their production are to operate under conditions of temperature control.

The accuracy of gear-cutting and alignment of pinions and wheels is to be demonstrated in the workshop to the satisfaction of the Surveyors.

### Trials

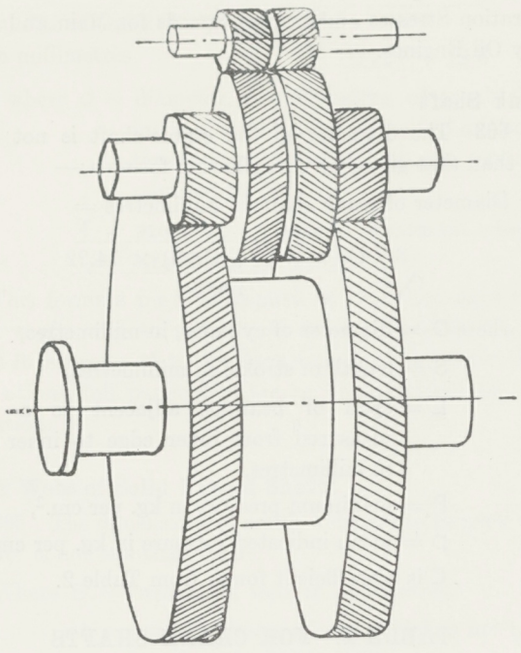
**512** The sea trials are to be of sufficient duration to prove the gears. On conclusion, all gears are to be opened up sufficiently to permit the Surveyors to make an inspection of the teeth.

For turbine gears having a loading factor exceeding K = 0,56 the tooth contact distribution is to be verified on completion of the sea trials. For this purpose and prior to the trials, the teeth of pinions and wheels are to be thinly coated with copper sulphate, an approved spirit lacquer, or other equivalent. The marking revealed by this inspection is to indicate freedom from hard bearing and not less than 70 per cent contact across the face width with satisfactory contact over the involute profile.

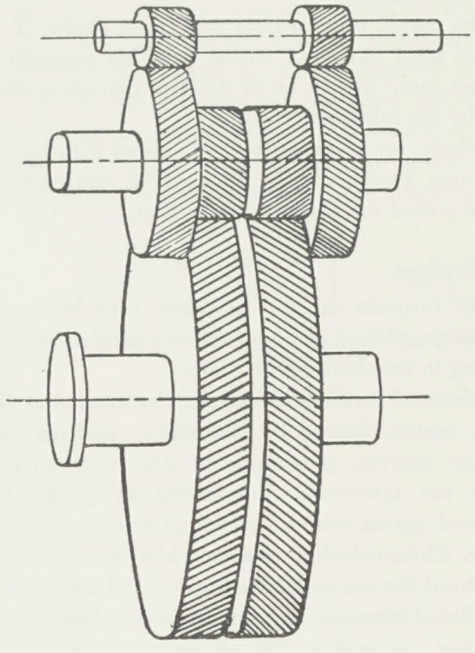
### Cross-Reference

**513** For lubricating oil systems, *see* E 9.

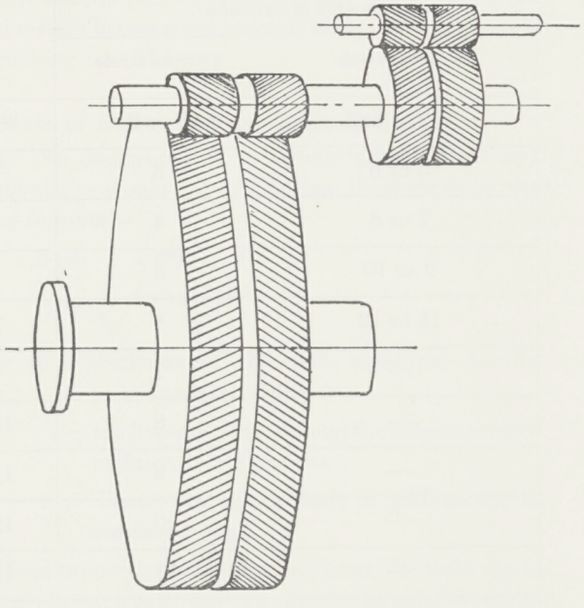
FIG. 1.—TYPICAL ARRANGEMENTS OF DOUBLE REDUCTION, DOUBLE HELICAL GEAR TRAINS



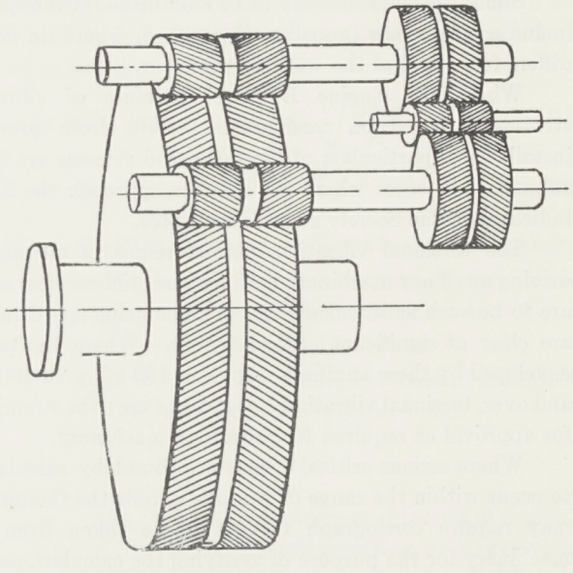
SPLIT SECONDARY



SPLIT PRIMARY



TANDEM



DUAL TANDEM

If flexible couplings are fitted between primary and secondary gears of "tandem" and "dual tandem" types, then these are described as "tandem articulated" and "dual tandem articulated", respectively.

## Section 6

### OIL ENGINES

**Dimensions of Shafts**

**601** The crank, intermediate and other shafts, if of ordinary mild steel having a tensile breaking strength of 44–52 kg. per mm.$^2$ are to be of not less diameters than those given by the following formulæ.

Where shafts are proposed to be made of high tensile steel, their sizes, together with the material specification, should be submitted for special consideration.

**Torsional Vibrations**

**602** The formulæ do not, however, take into consideration the possibility of dangerous torsional vibration stresses arising in the shafting.

Calculations of torsional vibration characteristics for the dynamic system formed by the engine, shafting and propeller, also gearing, generators or other components, where these are interposed, are to be submitted for consideration, together with plans of all shafting and of the propeller. These calculations should include:—

(*a*) Natural frequency tables for one and two noded modes of vibration, also higher modes if necessary.

(*b*) Vector summation for all orders of vibration occurring at speeds up to 20 per cent above the service speed.

(*c*) Particulars of the firing order in the case of four-cycle engines.

Similar calculations are to be submitted for the system including the spare propeller, if supplied, where its design differs from that of the working propeller.

Where the Engine Builders' estimate of vibration stresses is based on torsiograph records from previous installations, particulars of the estimated stresses are to be submitted in cases where the stresses approach the limits indicated in the Society's Guidance Notes.

The torsional vibration characteristics of oil engines driving auxiliary machinery used for essential services at sea are to be such as to ensure that the operating speed ranges are clear of significant critical speeds. Where the power developed by these auxiliary engines is 150 b.h.p. or 100 kW and over, torsional vibration calculations are to be submitted for approval as required for propelling machinery.

Where serious critical speeds are found by calculation to occur within the range of working speeds the Committee may require torsiograph records to be taken from the machinery for the purpose of verifying the calculations and may impose a restriction on continuous running at speeds where the stresses are considered to be excessive.

The submission of torsional vibration characteristics will not be required for ships classed for smooth water service when fitted with engines having powers less than 100 b.h.p.

*See* Chapter R(E) for Guidance Notes on Torsional Vibration Stresses and Critical Speeds for Main and Auxiliary Oil Engines.

**Crank Shaft**

**603** The diameter of the crank shaft is not to be less than that given by the following formula:—

Diameter of crank shaft, in millimetres =

$$\sqrt[3]{\frac{D^2 \times (PL + CpS) \times 14{,}22}{10000}}$$

where D = diameter of cylinder, in millimetres,

S = length of stroke, in millimetres,

L = span of bearings adjacent to a crank measured from inner edge to inner edge, in millimetres,

P = maximum pressure in kg. per cm.$^2$,

p = mean indicated pressure in kg. per cm.$^2$,

C is a coefficient found from Table 2.

**TABLE 2. FOR CRANK SHAFTS**

Maximum Pressure 35 kg. per cm.$^2$ and above

| Single Acting Engines | | |
|---|---|---|
| Number of Cylinders | | C |
| 4 Stroke Cycle | 2 Stroke Cycle | |
| 1, 2, 3 or 4 | 1 or 2 | 7,3 |
| 5 or 6 | 3 | 7,7 |
| 7 or 8 | 4 | 8,6 |
| 9 or 10 | 5 | 9,3 |
| 11 or 12 | 6 | 9,6 |
| — | 7 | 9,8 |
| — | 8 | 10,0 |
| — | 9 | 11,2 |
| — | 10 | 12,3 |
| — | 11 | 12,7 |
| — | 12 | 13,5 |

**604** Where it is proposed to make solid forged crank shafts of steel having a specified minimum tensile strength

greater than 44 kg. per mm.$^2$, but not exceeding 80 kg. per mm.$^2$, the diameter of the crank shaft is not to be less than given by the following formula:—

$$\text{Diameter of crank shaft in millimetres} = d \times \sqrt[3]{\frac{44}{0{,}72T + 12{,}6}}$$

where $d$ = diameter, in millimetres, of crank shaft made of steel having a specified minimum tensile strength of 44 kg. per mm.$^2$ as required by 603.

$T$ = proposed specified minimum tensile strength in kg. per mm.$^2$

This formula may be applied to built and semi-built crank shafts and to thrust and intermediate shafts, but where it is proposed to use high tensile material for these applications, full particulars are to be submitted for consideration.

### Crank Webs of Solid Forged Shafts

**605** The dimensions of crank webs are to be such that the $Bt^2$ is not less than $0{,}4d^3$.

Where $B$ = breadth of web, in millimetres,

$t$ = axial thickness of web, which is not to be less than $0{,}45d$, in millimetres,

$d$ = diameter of crank shaft required by 603 or 604, in millimetres.

Where the journals and pins overlap, allowance for the diagonal section between the journals and pins may be made in determining the $Bt^2$.

### Crank Webs of Built and Semi-Built Shafts

**606** The dimensions of the crank webs of built and semi-built shafts should not be less than those given by the following formulæ:—

$$h = 0{,}625 \times d$$

$$t = \sqrt{\frac{0{,}12 \times d^3}{h}}$$

where $h$ = thickness of the web, measured parallel to the axis, in millimetres,

$t$ = thickness of metal around the holes measured radially, in millimetres,

$d$ = diameter of crank shaft in millimetres, as required by 603.

If these proportions are departed from, the webs are to be of equivalent strength, but in no case is the axial thickness $h$ to be less than $0{,}525d$.

**607** Reference marks are to be provided on the outer junction of the crank webs with the journals and crank pins.

### Shrinkage Allowance

**608** Crank webs are to be securely shrunk on the journals and crank pins and the yield point of the material of the webs is to be not less than 22 kg. per mm.$^2$.

For solid journals and pins, the shrinkage allowance is to be between $\frac{1}{550}$ and $\frac{1}{700}$ of the diameter of these parts.

Where the journals and pins are hollow-bored, the diameter of the central hole is not to exceed one half of the diameter of the journal or pin and the shrinkage allowance is to be between those obtained by the following formulæ:—

$$\frac{1}{\left[550\text{-}400\left(\frac{H}{D}\right)^2\right]} \quad \text{and} \quad \frac{1}{\left[700\text{-}500\left(\frac{H}{D}\right)^2\right]}$$

where $H$ = diameter of hole in journal or pin, in millimetres,

$D$ = diameter of hole in crank web, in millimetres.

### Fillets and Oil Holes

**609** Fillets at the junctions of crank webs with crank pins or journals, where these are formed as solid forgings or castings, are to be machined to a radius of not less than 5 per cent of the diameter of the crank shaft and are to have a smooth finish.

Oil holes at the surfaces of crank pins and journals are to be rounded to an even contour with a smooth finish.

### Intermediate Shaft

**610** The diameter of the intermediate shaft $d$ is to be determined by formula (1) or, where the necessary particulars are available, by formula. (2)

$$d, \text{ in millimetres} = 25{,}4 \times C \sqrt[3]{\frac{BHP}{R}} \quad \text{.....(1)}$$

$$d, \text{ in millimetres} = 89 \sqrt[3]{\frac{BHP}{R}\left(\frac{X+A}{1+A}\right)} \quad \text{.....(2)}$$

Where $BHP$ = maximum designed brake horse power,

$R$ = revolutions per minute of the intermediate shaft at maximum power,

$C$ = coefficient obtained from Table 3,

$X$ = ratio of maximum to mean indicated torque at the after cylinder,

$A = \frac{Je}{Jp}$

$Je$ = total mass moment of inertia of engine, including reciprocating and revolving parts and flywheel, also gearing if fitted,

$Jp$ = mass moment of inertia of propeller including entrained water referred to crank shaft speed.

NOTE 1.—Formula (1) is applicable only to single piston in-line engines with approximately equal firing intervals.

NOTE 2.—Formula (2) is applicable to all engines without restriction of any kind and may allow, in some cases, a smaller shaft diameter than formula (1).

NOTE 3.—Where a percentage figure for the mass of water entrained by the propeller is not available, it may be taken as 25 per cent.

TABLE 3

| 4 STROKE SINGLE ACTING | | 2 STROKE SINGLE ACTING | |
|---|---|---|---|
| Number of Cylinders | C | Number of Cylinders | C |
| 1 to 4 | 4,30 | 1 or 2 | 4,50 |
| 5 | 4,15 | 3 | 4,20 |
| 6 | 4,05 | 4 | 4,00 |
| 7 | 4,00 | 5 | 3,90 |
| 8 | 3,90 | 6 | 3,80 |
| 9 | 3,85 | 7 | 3,75 |
| 10 | 3,70 | 8 | 3,65 |
| 11 and over | 3,55 | 9 & over | 3,55 |

NOTE.—The Rule diameter of the intermediate shaft may be reduced by 3,5 per cent for ships classed exclusively for smooth water service and by 1,75 per cent for ships classed exclusively for service on the Great Lakes.

### Flywheel Shaft

**611** The diameter of the flywheel shaft is to be not less than that required for the crank shaft. Shafts carrying light turning wheels are excepted from this requirement.

### Wheel Shafts of Geared Oil Engines

**612** Where there are two pinions geared into the wheel opposite, or nearly opposite to one another, the diameter of the wheel shaft is to be not less than 1,1 times that required for the intermediate shaft.

Where there is only one pinion geared into the wheel, or where there are two pinions which are set to subtend an angle at the centre of the shaft of less than 120 degrees, the diameter of the shaft at the wheel and the adjacent journals is to be not less than 1,16 times that required for the intermediate shaft. Abaft the journals the shaft may be gradually tapered down to the diameter required for the intermediate shaft.

### Thrust Shaft

**613** The diameter at the collars of the thrust shaft transmitting torque is to be not less than 1,15 times that required for the intermediate shaft; outside the collars the diameter may be tapered down to that required for the intermediate shaft.

### Tube Shaft

**614** The diameter of the tube shaft (i.e. the shaft which passes through the stern tube, but does not carry the propeller) is not to be less than 1,14 times that required for the intermediate shaft, and any part of the shaft within or without the tube which may be exposed to sea water is not to be less than 1,17 times that required for the intermediate shaft.

### Screw Shaft

**615** The diameter of the screw shaft carrying the propeller is not to be less than that given by the following formula:—

$$\text{Diameter of screw shaft, in millimetres} = 1{,}14d + \frac{P}{C}$$

where $d$ = diameter required for the intermediate shaft, in millimetres,

$P$ = diameter of the propeller, in millimetres,

$C$ = 144 when the shaft is fitted with a continuous liner or is oil lubricated and provided with an approved type of oil sealing gland,
100 for other shafts.

Screw shafts which run in stern tubes may have the end forward of the stern gland tapered down to a diameter, at the coupling flange, of 1,14 times that required for the intermediate shaft. Abrupt changes in shaft section at the screw shaft to intermediate shaft couplings should be avoided.

**616** The propeller boss is to be a good fit on the screw shaft cone. The length of the forward fitting surface should be about one diameter. The forward edge of the bore of the propeller boss is to be rounded to about a 6 mm. radius.

### Propeller Keys and Keyways

**617** Round ended or sled-runner ended type keys are to be used and the keyways in the propeller boss and cone of the screw shaft are to be provided with a smooth fillet at the bottom of the keyways. The radius of the fillet is to be at least 0,0125 of the diameter of the screw shaft at the top of the cone. The sharp edges at the top of the keyway are to be removed.

Two screwed pins should be provided for securing the key in the keyway and the forward pin should be placed at least one third of the length of the key from the end. The depth of the tapped holes for the screwed pins should not exceed the pin diameter, and the edges of the holes should be slightly bevelled.

The distance between the top of the cone and the forward end of the keyway is to be not less than 0,2 of the diameter of the screw shaft at the top of the cone.

The effective sectional area of the key in shear, in square millimetres, is to be not less than $\frac{d^3}{2{,}5d_1}$

where $d$ = diameter required for the intermediate shaft, in millimetres,

$d_1$ = diameter of shaft at mid-length of the key, in millimetres.

### Hollow Shafts

**618** Where the thrust, intermediate, tube and screw shafts have central holes, the dimensions of the shafts as determined by the foregoing formulæ need not be increased, provided the diameter of the central hole in a shaft does not exceed one-third of the shaft diameter.

### Bronze Liners on Shafts

**619** The thickness of liners fitted on screw shafts or on tube shafts, in way of the bushes, is not to be less, when new, than that given by the following formula:—

$$t \text{ in millimetres} = \frac{D + 230}{32}$$

where $t$ = thickness of the liner, in millimetres,

$D$ = diameter required for the screw or tube shaft under the liner, in millimetres.

The thickness of a continuous liner between the bushes is not to be less than 0,75 t.

**620** Continuous liners should be cast in one piece or, if made of two or more lengths, the junctions of the separate pieces are to be made by fusion through the whole thickness of the liner.

The material of bronze liners is to be suitable for welding and have a composition free from lead. The composition of the electrodes or filler rods should also be lead free.

Where composite liners are made by butt welding, provision is to be made for contraction of the weld by arranging for the abutting portions of the liner on each side of the weld to be free of the shaft. The total free length of the liners if possible should be about three times the diameter of the shaft. To prevent damage to the surface of the shaft during welding, a strip of asbestos or other heat resisting material covered by a copper strip should be inserted between the shaft and liner in way of the joint. Other methods for welding this joint may be accepted if approved. The welding is to be carried out by an approved method and to the Surveyors' satisfaction.

Each continuous liner or length of liner is to be tested by hydraulic pressure to 2 kg. per cm.$^2$ after rough machining.

Liners are to be carefully shrunk on, or forced on to the shafts by hydraulic pressure. Pins are not to be used to secure the liners.

If the liner does not fit tightly between the bearings in the stern tube, the space between the shaft and the liner is to be charged or forced with a plastic material insoluble in water and non-corrosive.

**621** Effective means are to be provided for preventing water from having access to the shaft at the part between the after end of the liner and the propeller boss.

### Stern Bush

**622** The length of the bearing in the stern bush next to and supporting the propeller is to be as follows:—

(*a*) For water-lubricated bearings which are lined with lignum vitae, rubber composition or approved plastic material, the length is to be not less than four times the diameter for the screw shaft under the liner.

Forced water lubrication is to be provided for all bearings lined with rubber or plastic and for those bearings lined with lignum vitae where the shaft diameter is 380 mm. or over. The supply of water may come from a circulating pump or other pressure source. Flow indicators are to be provided for the water service to plastic and rubber bearings. The water grooves in the bearings should be of ample section and of a shape which will be little affected by weardown, particularly for bearings of the plastic type.

The shut-off cock or valve controlling the supply of water is to be fitted direct to the after peak bulkhead or to the stern tube where the water supply enters the stern tube forward of the bulkhead.

(*b*) For bearings which are white metal lined, oil lubricated and provided with an approved type of oil sealing gland, the length of the bearing is to be such that the nominal bearing pressure resulting from the weight of propeller and shaft will not exceed 5 kg. per cm.$^2$. In no case is the length of

the bearing to be less than 2½ times the diameter required for the screw shaft. The weight of the propeller and of screw shaft, and the type of oil sealing gland are to be stated when the plans are submitted for approval.

(*c*) For bearings of cast iron and bronze which are oil lubricated and fitted with an approved oil gland, the length of the bearing is, in general, to be not less than 4 times the diameter required for the screw shaft.

(*d*) For bearings which are grease lubricated the length of the bearing is to be not less than 4 times the diameter required for the screw shaft.

Oil sealing glands fitted in ships classed for unrestricted service must be capable of accommodating the effects of differential expansion between hull and line of shafting in sea temperatures ranging from Arctic to Tropical. This requirement applies particularly to those glands which span the gap and maintain oil tightness between the sterntube and the propeller boss.

Where a tank supplying lubricating oil to the stern bush is fitted it is to be located above the load water line and is to be provided with a low level alarm device in the engine room.

Where stern bush bearings are oil lubricated, provision should be made for cooling the oil by maintaining water in the after peak tank above the level of the stern tube or by other approved means. Means for ascertaining the temperature of the oil in the stern tube should also be provided.

NOTE.—Where there is compliance with the terms of (*b*) and (*c*) to the Surveyors' satisfaction a screw shaft will be assigned the notation O.G. in the supplement to the Register Book for periodical survey purposes (*see* C 1101).

Screw shafts which are grease lubricated are not eligible for the O.G. notation.

### Coupling Bolts

**623** With coupling bolts of ordinary mild steel having a minimum tensile strength of 44 kg. per mm.$^2$, the diameter of the bolts at the joining faces of the couplings is not to be less than that given by the following formula:—

$$\left.\begin{array}{l}\text{Diameter of coupling bolts, in millimetres, which should not be greater than the thickness of the coupling flange.}\end{array}\right\} = C\sqrt{\frac{d^3}{n \times r}}$$

Where $n$ = number of bolts in the coupling,

$r$ = radius of pitch circle of bolts, in millimetres.

For coupling bolts for thrust, intermediate, tube and screw shafts,

$C = 0{,}6$,

$d$ = diameter required for intermediate shaft, in millimetres.

For coupling bolts for crank shafts,

$C = 0{,}5$,

$d$ = diameter required for the crank shaft, in millimetres.

Where the specified minimum tensile strength of the crank shaft is greater than 44 kg. per mm.$^2$, and the diameter of the shaft is determined by 604, the coupling bolts for this shaft are to be of equivalent strength.

**624** For thrust, intermediate, tube and screw shafts, the thickness of coupling flanges at the pitch circle of the bolt holes is to be not less than 0,27 of the diameter required for the intermediate shaft.

The fillet radius at the base of the coupling flange is to be not less than 0,08 of the diameter of the shaft at the coupling, but in the case of crank shafts, the fillet radius at the centre coupling flanges may be 0,05 of the diameter of the shaft at the coupling. The fillets are to have a smooth finish and should not be recessed in way of nuts and bolt heads.

Where a coupling is shrunk on the parallel portion of a shaft or is mounted on a slight taper by means of the oil pressure injection method, the interference fit is to be in general accordance with the requirements of 608.

Where couplings are separate from the shafts, provision is to be made to resist the astern pull.

All couplings which are attached to shafts are to be of approved dimensions.

*See* paragraph 108, Chapter R(E)—Guidance Notes on Torsional Vibration Stresses.

### Propellers

**625** Where bronze or cast steel is used for propellers or propeller blades, the materials should comply with the relevant requirements of Chapter P, or an approved specification.

Cast iron propellers are to be made of a high duty iron of at least 27 kg. per mm.$^2$ tensile strength, or of a nodular or spheroidal graphite ductile type cast iron.

## CAST IRON CRANK SHAFTS

### General

**626** Where it is proposed to make crank shafts of cast iron, the material specification and the dimensions of the shaft are to be submitted for special consideration.

### Material

**627** The material specification should state the type of cast iron, the heat treatment, and mechanical properties, including the specified minimum tensile strength appropriate to the section of the crank shaft casting.

**628** Any suitable type of high duty cast iron may be used, provided the minimum specified tensile strength is between 32 and 76 kg. per mm.$^2$ Crank Shafts are to be cast at a foundry approved for the production of cast iron crank shafts. (*See* P 19).

### Crank Shafts

**629** The diameter of the crank shaft is not to be less than that given by the following formula:—

Diameter of crank shaft in millimetres

$$= d \times \sqrt[3]{\frac{22}{0{,}3T + 7{,}9 - \frac{d}{48}}}$$

where $d$ = diameter in millimetres required by 603 for a steel crank shaft having a tensile strength of 44 kg. per mm.$^2$

$T$ = specified minimum tensile strength of cast iron in kg. per mm.$^2$ which is not to be less than 32 kg. per mm.$^2$

**630** Special consideration will be given to crank shafts which have been designed and developed for optimum fatigue strength with cranks of the most favourable shape, and some allowance made for the superior strength thereby obtained. Particulars of any relevant tests or experience should be submitted.

### Crank Webs

**631** The breadth of the webs should not be less than 1,33 times and the thickness not less than 0,56 times the diameter of the shaft required by 629. If these proportions are departed from, the webs are to be of equivalent strength.

### Fillets and Oil Holes

**632** Fillets at the junctions of crank webs with crank pins or journals are to be machined to a radius of not less than 5 per cent of the diameter of the crank shaft and are to have a smooth finish.

Oil holes at the surfaces of crank pins and journals are to be rounded to an even contour with a smooth finish.

## Section 7

## GENERAL REQUIREMENTS FOR OIL ENGINES AND STARTING AIR COMPRESSORS

### General

**701** Special attention is to be given to the ventilation of the engine room.

**702** Cylinder relief valves are to be fitted to engines of 203 mm. bore or over. The valves are to be loaded to not more than 40 per cent above the designed maximum pressure and are to discharge where no damage can occur.

**703** Where scavenging is effected by a single independent scavenging blower alternative or duplicate means for driving the blower are to be provided ready for use.

**704** Scavenge manifolds of two-stroke main engines are to be provided with explosion relief valves.

**705** The exhaust pipes and silencer are to be water cooled or efficiently lagged to prevent damage by heat; if the exhaust is led overboard near the water-line, means are to be provided to prevent water from being syphoned back to the engine.

Where the exhaust is cooled by water spray, the exhaust pipes are to be self-draining overboard.

Where the exhausts of two or more engines are led to a common silencer or exhaust gas-heated boiler or economiser an isolating device is to be provided in each exhaust pipe.

For alternatively fired furnaces of boilers using exhaust gases and oil fuel, the exhaust gas inlet pipe is to be provided with an isolating device and interlocking arrangements whereby oil fuel can only be supplied to the burners when the isolating device is closed to the boiler.

In two-stroke main engines fitted with exhaust gas turbo-blowers which operate on the impulse systems, provision is to be made to prevent broken piston rings entering the turbine casing and causing damage to blades and nozzle rings.

**706** An efficient governor is to be fitted to each main engine to prevent excessive racing.

**707** Auxiliary engines intended for driving electric generators are to be fitted with governors which, with fixed setting, are to control the speed within the following limits:—

10 per cent momentary variation and 6 per cent permanent variation in speed when full load is suddenly taken off or put on, but for any A.C. installation the permanent speed variations of the machines intended

for parallel operation are to be equal within a tolerance of ± 0,5 per cent.

### Starting Arrangements

**708** Equipment for starting the main and auxiliary engines is to be provided so that the necessary initial charge of starting air or initial electric power can be developed on board ship without external aid. If for this purpose an emergency air compressor or electric generator is required, these units are to be power driven by hand starting oil engine or steam engine, except in the case of small installations where a hand operated compressor of approved capacity may be accepted.

**709** Two or more starting and manœuvring air compressors are to be fitted of sufficient total capacity for the requirements of the main engines.

The compressors are to be so designed that the temperature of the air discharged to the starting air receivers will not substantially exceed 93° C. in service. A small fusible plug or an alarm device operating at 121° C. is to be provided on each compressor to give warning of excessive air temperature. The emergency air compressor is excepted from these requirements.

Each compressor is to be fitted with a safety valve so proportioned and adjusted that the accumulation with the outlet valve closed will not exceed 10 per cent of the maximum working pressure. The casings of the cooling water spaces are to be fitted with a safety valve or bursting disc so that ample relief will be provided in the event of the bursting of an air cooler tube. It is recommended that compressors be cooled by fresh water.

**710** Where the main engines are arranged for air starting the total air receiver capacity is to be sufficient to provide, without replenishment, not less than twelve consecutive starts of each main engine if of the reversible type and not less than six consecutive starts if of the non-reversible type. In passenger ships, at least two air receivers are to be provided. For scantlings and fittings of air receivers *see* J 24.

**711** Where main engines are fitted with electric starters, two batteries are to be fitted of sufficient combined capacity without recharging to provide the number of starts of the main engines as required by 710. In other respects batteries are to comply with the requirements of M 13.

### Starting Air Pipe Systems and Safety Fittings

**712** In designing the compressed air installation care is to be taken that the compressor air inlets will be located in an atmosphere reasonably free from oil vapour or alternatively an air duct from outside the machinery space is to be led to the compressors.

The air discharge pipe from the compressors is to be led direct to the starting air receivers. Provision is to be made for intercepting and draining oil and water in the air discharge for which purpose a separator or filter is to be fitted in the discharge pipe between compressors and receivers.

The starting air pipe system from receivers to main and auxiliary engines is to be entirely separate from the compressor discharge pipe system. Stop valves on the receivers are to permit of slow opening to avoid sudden pressure rises in the piping system. Valve chests and fittings in the piping system are to be of ductile material.

Drain valves for removing accumulations of oil and water are to be fitted on compressors, separators, filters, receivers and any low-level pipe lines.

The starting air piping system is to be protected against the effects of explosions by the following arrangements. An isolating non-return valve or equivalent is to be provided at the starting air supply connection to each engine. In direct reversing engines bursting discs or flame arresters are to be fitted at the starting valves on each cylinder; in non-reversing and auxiliary engines at least one such device is to be fitted at the supply inlet to the starting air manifold on each engine. The fitting of bursting discs or flame arresters may be waived in small ships where the power of the main engine is less than 1500 b.h.p. provided all the pipes in the system are made at least twice as thick as required by E 506 or E 512.

Alternative safety arrangements may be submitted for consideration.

### Crank Case Safety Fittings

**713** Crank cases are to be provided with lightweight spring-loaded valves or other quick-acting and self-closing devices to relieve the crank cases of pressure in the event of an internal explosion and to prevent any inrush of air thereafter. The valves are to be designed to open at a low pressure of about 0,1 kg. per cm.$^2$.

The valve lids are to be made of ductile material capable of withstanding the shock of contact with stoppers at the full open position.

In large engines at least one of these valves is to be fitted to each cylinder crank case and separate gear or chain case for camshaft or similar drive. In small engines where there is free communication between all cylinder crank cases, valves are to be provided in numbers not less than given in Table 4. Where only two valves are required they are to be located at or near each end of the crank case. In engines having cylinders of less than 150 mm. bore or crank

case volumes of less than 0,57 m.$^3$, relief valves may be omitted.

The discharge from the valves is to be shielded where necessary by flame guard or flame trap to minimise the possibility of danger and damage arising from the emission of flame.

**714** The minimum area of crank case relief valves is to be determined as follows:—

$$A = \frac{V \times 114}{N}$$

where A = minimum effective area of each valve, in square centimetres,

V = total gross volume of crank case in cubic metres,

N = number of relief valves fitted to each engine, which is to be not less than given in Table 4.

No valve is to be less than 75 mm. in diameter or the equivalent area.

TABLE 4

| Diameter of Engine Cylinders Millimetres | Number of Cylinders per Engine | Minimum Number of Relief Valves per Engine |
|---|---|---|
| 150 to 230 | Up to 8 | 2 |
| | Over 8 | 3 |
| Over 230 to 305 | Any Number | One for each* Alternate Cylinder |
| Over 305 | Any Number | One per Cylinder |

*For engines having 5, 7, 9, etc. cylinders, the number of relief valves is to be not less than 3, 4, 5, etc., respectively.

In general, for "V" engines half the number of cylinders may be taken in using this table.

Alarms giving warning of the overheating of engine running parts, indicators of excessive wear of thrusts and other parts, and detectors of smoke in the crank case are recommended as means for reducing the explosion hazard. These devices should be arranged to give an indication of failure of the equipment or of the instrument being switched off when the engine is running. Where approved devices of this nature are fitted, a reduction in the area of relief valves up to a maximum of 50% may be permitted subject to special approval.

**715** Crank cases and their doors are to be of robust construction and the doors are to be securely fastened so that they will not be readily displaced by an explosion.

**716** Where crank case vent pipes are fitted, they are to be made as small as practicable to minimise the inrush of air after an explosion. Vents from crank cases of main engines are to be led to a safe position on deck or other approved position.

Lubricating oil drain pipes from engine sump to drain tank are to be submerged at their outlet ends. Where two or more engines are installed, vent pipes, if fitted, and lubrication oil drain pipes are to be independent to avoid intercommunication between crank cases.

**717** Crank cases of large starting air compressors are to be fitted with explosion relief devices as required for auxiliary engines in cases where the crank case volume is 0,57 m.$^3$ and over.

### Crank Case Lighting

**718** Where interior lighting is provided it is to be flame proof in relation to the interior and details are to be submitted for approval. No wiring is to be fitted inside the crank case.

### Hydraulic Tests

**719** Where main and auxiliary engine cylinder covers and cylinders not fitted with liners cannot be readily examined internally they are to be tested by hydraulic pressure to 1,5 times the maximum working pressure.

**720** Air compressor cylinders, covers, intercoolers and aftercoolers are to be tested by hydraulic pressure to twice their maximum working pressure.

**721** Cylinder liners are to be tested by hydraulic pressure to not less than 7 kg. per cm.$^2$

**722** The water jackets of cylinders, and the cooling passages of cylinder covers and pistons, are to be tested by hydraulic pressure to 2,1 kg. per cm.$^2$

**723** Fresh water and lubricating oil coolers are to be tested by hydraulic pressure to twice the working pressure with a minimum of 3,5 kg. per cm.$^2$ on the fresh water and lubricating oil side, and a minimum of 2,1 kg. per cm.$^2$ on the cooling water side.

### Astern Power

**724** Ships are to have sufficient power for going astern to secure proper control of the ship in all normal circumstances.

### Trials

**725** The sea trials are to be of sufficient duration to prove the machinery under power and normal manœuvring conditions.

It is to be demonstrated that the capacity of starting air receivers is adequate to provide the required number of starts of the main engines.

In the case of passenger ships, the ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, under normal manœuvring conditions, and so bring the ship to rest from maximum ahead service speed is to be demonstrated at the sea trials.

All trials are to be to the Surveyor's satisfaction.

### Cross-references

**726** Engines intended for driving electric generators are to comply with the requirements of M4 and M17 where applicable.

**727** Where auxiliaries are worked by electricity, the cables, motors, control gear and electrical spares are to comply with the requirements of Chapter M.

**728** The pumping arrangements, cooling water and lubricating oil systems are to comply with the requirements of Chapter E.

**729** All oil fuel pipes, tanks and their fittings are to comply with the requirements of D 20 and Chapter E.

### Spare Gear

**730** For lists of spare gear to be carried, *see* Chapter K.

### Periodical Surveys

**731** For periodical survey requirements, *see* C5 and C7.

## Section 8

### STRENGTHENING FOR NAVIGATION IN ICE

**801** Where the notation "Ice Class 1, 2 or 3" is desired, the following requirements are to be complied with, so far as these are applicable.

### Power of Propelling Machinery

**802** The power delivered to the propeller shafting (s.h.p.) is not to be less than $L \times B \times C$

Where $L$ = length of ship, between perpendiculars, in metres,

$B$ = breadth of ship, moulded, in metres,

$C$ = coefficient given in Table 5 for each class.

### Main Engine Shafting

**803** The shafting and couplings are to be steel and the diameters of the shafting as required by the rules for ocean-going service are to be increased by the percentages stated in Table 5. No increase in the diameter of crankshafts of oil engines is required.

### Gearing

**804** If gearing is fitted between the engine and propeller shafting, the gearing is to be designed and constructed to transmit torque in excess of that corresponding to the engine power by the percentages given in Table 5.

### Turbines

**805** Where turbines are used for the propulsion of ships intended for Class 1 or 2 ice strengthening, a slip coupling is to be fitted between the turbines and propeller shafting.

### Electric Motors

**806** Where direct current electric motors are used for the propulsion of ships intended for Class 1 and 2 ice strengthening, provision is to be made for automatically limiting the transmitted torque to a safe value.

### Propellers

**807** Propellers and propeller blades are to be of cast steel or bronze having a tensile strength and elongation of not less than 44 kg. per mm.$^2$ and 20 per cent on a gauge length of 50 mm. The material is to comply with the requirements of P 5 or P 10.

Propellers intended for Class 1, 2 or 3 ice strengthening are to be designed so that the blade root and the blade tip thicknesses are not less than obtained by the following formulæ. Alternatively, a detailed stress computation for the blades is to be submitted for consideration.

Blade root thickness

$$T = 25{,}4 \times K \sqrt{\frac{SHP \times 44}{R \times S \times N \times L}}$$

where $K = C - \frac{30P}{D} + \frac{AR}{1{,}4D}$

Blade tip thickness

$$t = \sqrt{\frac{D \times R}{30 \times S}}$$

where T = blade thickness at 25 per cent radius, in millimetres,
t = blade thickness at tip, in millimetres,
SHP = maximum designed shaft horse power,
R = revolutions per minute at maximum power,
D = propeller diameter, in millimetres,
P = mean pitch, in millimetres,
L = length of blade section at 25 per cent radius, in millimetres,
A = rake, in millimetres,
N = number of blades,
C = 111 for Ice Class 1
= 103 ,, ,, ,, 2
= 98 ,, ,, ,, 3
S = tensile strength of material, in kg. per mm.$^2$

The blade thicknesses at sections between 25 per cent radius and the tip are not to be less than included by the straight lines joining thicknesses T and t. The edges of blades are to be suitably thickened for the operating conditions.

A plan, in triplicate, of the propeller, together with details of material, power and revolutions per minute and other particulars required for calculating the Rule thickness of the blades, are to be submitted for approval by the propeller designers.

TABLE 5

| Class | 1 | 2 | 3 |
|---|---|---|---|
| Power Coefficient C... ... | 1,58 | 1,17 | 0,90 |
| Screw Shaft, increase in diameter ... ... ... | 15% | 8% | 5% |
| Crank, Thrust and Intermediate Shaft, increase in diameter ... ... ... | 8% | 4% | — |
| Gearing, torque increase ... | 25% | 15% | — |

### Ship Side Valves

**808** All sea inlet and overboard discharge valves are to be provided with a low pressure steam system or other ice melting means for clearing purposes. *See* E 271.

**809** Connections are to be fitted between the cooling water overboard discharge lines and sea inlets for main and auxiliary engine cooling water systems so that warm water may be used to assist in maintaining the suction pipes free from ice.

Where the cooling water inlet valves are fitted to a common water box, the connection from the cooling water discharge line may be led to the water box in a position as near as possible to the inlet valves.

**810** In motor ships where clearing steam is not available fire pumps are to be provided with suctions from the main cooling water inlet pipe.

### Cross-references

**811** For hull requirements *see* D 10 and for general requirements for ship side valves, *see* E 267 to E 271.

## Section 9

## WELDED STRUCTURES FOR STEAM RECIPROCATING AND OIL ENGINES

### General

**901** The requirements of this section are applicable to engines for main propelling purposes.

### Plans

**902** Before construction is commenced plans of bedplates, crankcases, frames and entablatures, including details of the welded joints, materials, electrodes and heat treatment are to be submitted for consideration.

An outline of the welding procedure and fabrication method and sequence is also to be submitted for information.

NOTE: It will not be necessary for plans and particulars to be submitted for each ship provided the basis plans for the engine size and type have previously been approved as meeting the requirements of these Rules. Any alterations to basis design, materials and manufacturing procedure are to be re-submitted for consideration.

### Materials

**903** Plates, sections, forgings and castings are to be of welding quality to an approved specification with a carbon content generally not exceeding 0,23 per cent, and are to be tested in accordance with the requirements of Chapter P. Steels with higher carbon contents may be approved subject to special tests to prove weldability.

### Welded Joints

**904** Joints in parts of the engine structure which are stressed by the main gas, steam or inertia loads are to be designed as continuous full strength welds and for complete fusion of the joint. They are to be so arranged that, in general, welds do not intersect, and that welding and inspection can be effected without difficulty. Abrupt changes in plate section are to be avoided and where plates of substantially unequal thickness are to be butt welded, the thickness of the heavier plate is to be gradually tapered to that of the thinner plate. Tee joints are to be made with full bevel or equivalent weld preparation to ensure full penetration.

In single plate transverse girders the castings for main bearing housings are to be formed with web extensions which can be butt welded to the flange and vertical web plates of the girder. Stiffeners in the transverse girder are to be attached to the flanges by full penetration welds.

### Construction

**905** Plates and weld preparations are to be accurately machined or flame-cut to shape. Flame-cut surfaces are to be cleaned by machining or grinding; if the flame-cut surfaces are smooth, wire brushing may be accepted.

Before welding is commenced the component parts of bedplates and framework are to be accurately fitted and aligned. The welding is to be done in positions free from draughts and is to be downhand wherever practicable. Electrodes are to be of an approved type. Pre-heating is to be adopted when welding heavy plates or sections. The finished welds are to have an even surface and be free from undercutting. Welds attaching bearing housings to the transverse girders are to have a smooth contour and if necessary are to be made smooth by grinding.

### Heat Treatment

**906** Bedplates of oil engines are to be stress relieved except for engine types where the bedplate as a whole is not subjected to direct loading from the cylinder pressure. For the latter types, and for all steam engines, only the transverse girder assemblies need be stress relieved.

Stress relieving is to be done by heating the welded structure uniformly and slowly to a temperature between 600° C. to 650° C. (1112° F. to 1202° F.), holding that temperature for not less than one hour per 25 mm. of maximum plate thickness and thereafter allowing the structure to cool slowly in the furnace.

### Inspection

**907** Welded engine structures are to be examined during fabrication, special attention being given to the fit of component parts of major joints prior to welding. On completion of welding and stress relieving, all welds are to be examined. Welds in transverse girder assemblies are to be crack detected by an approved method to the satisfaction of the Surveyors. Other joints are to be similarly tested if required by the Surveyors.

The whole of the welding work is to be to the satisfaction of the Surveyors.

### Design Recommendations

It is recommended that bedplates and major components of engine structures should be made with a minimum number of welded joints.

Double welded butt type joints should be adopted wherever possible in view of their superior fatigue strength.

Girder and frame assemblies should, as far as possible, be made from one plate or slab, shaped as necessary, rather than by welding together a number of small pieces.

Steel castings should be used for parts which would otherwise require complicated weldments.

Care should be taken to avoid stress concentrations such as sharp corners and abrupt changes in section.

# Chapter J

# BOILERS AND OTHER PRESSURE VESSELS

## CYLINDRICAL BOILERS

### Section 1

### GENERAL REQUIREMENTS

**101** In the design and construction of boilers the following conditions are to be observed.

**102** The materials used are to be in accordance with the relevant requirements of Chapter P.

**103** Where the joints in the shells of boilers are made by means of welding, the shells are to be constructed in accordance with the requirements of J 16, J 18, J 19 and J 22, in so far as they are applicable.

**104** Where the joints in the shells of boilers are riveted, the shells are to be constructed in accordance with the requirements of J 5.

**105** All steel plates which are welded, dished, flanged or locally heated are to be afterwards efficiently heat treated.

**106** Butt straps are to be cut from plates and not from rolled strips.

**107** All rivet holes are to be drilled, and as far as possible they are to be drilled in place. After drilling the plates the burrs are to be removed and the faying surfaces of the plates cleaned, and the sharp outer edges of holes also removed.

**108** Steel stays are not to be welded. If plus threads are desired, the ends of the stay bars may be upset or the bars may be drawn down in the central portions from bars originally of the size of the ends. In either of these two cases the bars are to be subsequently annealed throughout. In double-ended boilers the through longitudinal stays are to be supported at or near the middle of their length.

**109** Screw stays of combustion chambers where fitted with nuts are to be, as far as possible, normal to the chamber plates. Where this is not possible they are to be fitted with taper washers to provide a fair bed for the nuts.

**110** Nuts to screw stays in combustion chambers are to be not less than 19 mm. thick for stays up to 38 mm. diameter over threads, 22 mm. thick for 41 and 45 mm. stays, 25 mm. thick for 48 and 51 mm. stays, and 29 mm. thick for stays over 51 mm. in diameter. The nuts are to be made of solid mild steel or of iron which is to be without weld.

**111** Screw stays 32 mm. in diameter and above should have 9 threads per 25,4 mm., and all stays 51 mm. in diameter and above passing through plates, and secured by nuts on each side of the plate, should have not more than 6 threads per 25,4 mm.

**112** Where jointed longitudinal stays are fitted between the front and back tube plates they are to be fitted with pins having an effective sectional area not less than 25 per cent in excess of that of the stay. The pins may be slack in the holes, the total slackness being not more than 1,5 mm. The pins are to be as close as possible to the shoulder of the eye forging. The shoulder of the forging is to have a diameter not less than 25 mm. greater than the diameter of the hole.

**113** The end plates in the steam space in way of uptakes are to be shielded from contact with the heated gases.

**Cross-reference**

**114** For requirements as to smoke box doors and the omission of dampers in oil-fired boilers, *see* E 332 and E 333.

### Section 2

### ACCESS ARRANGEMENTS

**201** Manholes in cylindrical shells are to have their shorter axes arranged longitudinally. Where the cylindrical shell is cut for a manhole, compensation is to be provided and is to be such that the strength in way of the hole is not less than that required for the longitudinal joint.

**202** Where a flat plate is flanged for stiffening it at a manhole or sight hole, to permit the same working pressure as would be allowed upon an unpierced plate, the depth of the flange measured in millimetres from the outer surface is to be at least equal to $\sqrt{T \times W}$ where T is the thickness of the plate in millimetres and W is the minor axis of the hole in millimetres.

**203** The doors to manholes, mudholes, and sight holes are to be built up or pressed to shape and annealed, or made from one thickness of plate with a machined recess for the jointing material. Their spigot part or the recess is not to have a greater clearance than 1,5 mm. all round, i.e., the axes of the opening are not to exceed those of the door by more than 3 mm.

**204** The studs for securing all doors are to be screwed through the plate, and they are to be fitted with nuts on the inside or bolts may be used screwed through the plate with the heads inside.

**205** All boilers are to be provided, where possible, with means for ingress to permit of examination and cleaning of the inner surfaces of plates and tubes exposed to flame. Where the boilers are too small to permit of this there are to be sight holes and mudholes sufficiently large and numerous to permit of the inside being satisfactorily cleaned.

**206** Where the cross tubes of vertical boilers are large there is to be a sight hole in the shell opposite to one end of each tube sufficiently large to permit the tube to be examined and cleaned. These sight holes are to be in positions accessible for that purpose.

## Section 3

### HYDRAULIC TESTS

#### Boilers

**301** In all new boilers working at pressures up to 7 kg. per cm.$^2$ the hydraulic test is to be twice the working pressure. For boilers working at pressures greater than 7 kg. per cm.$^2$ the hydraulic test pressure is to be 1,5 times the working pressure plus 3,5 kg. per cm.$^2$

#### Boiler Mountings

**302** All boiler mountings are to be subjected to a hydraulic test of twice the working pressure with the exception of feed check valves which are to be tested to 2,5 times the working pressure. The test pressures need not, however, be more than 70 kg. per cm.$^2$ above the working pressure.

## Section 4

### MOUNTINGS AND FITTINGS FOR CYLINDRICAL AND VERTICAL BOILERS AND UNFIRED STEAM GENERATORS

#### General

**401** Valves over 38 mm. diameter are to be fitted with outside screws and the covers are to be secured by bolts or studs. All valves are to be arranged to be shut with a right-hand (clockwise) motion of the wheels.

**402** All cocks and valves connected to the boiler are to be such that it is seen without difficulty whether they are open or shut. Where boiler mountings are secured by studs, the studs are to have a full thread holding in the plate for a length of at least one diameter. If the stud hole penetrates the whole thickness of the plate the stud is to be screwed right through the plate and is to be fitted with a nut inside the boiler. Where bolts are used for securing mountings they are to be screwed right through the plate with their heads inside the boiler.

**403** Where a superheater is fitted which can be shut off from the boiler it is to be provided with a separate safety valve fitted with easing gear. The valve as regards construction is to comply with the regulations for ordinary safety valves, but the easing gear may be fitted to be workable from the stokehold only. The superheater is also to be fitted with a drain cock or valve to free it from water when necessary.

**404** Safety valve chests and other boiler and superheater mountings subjected to pressures exceeding 10,5 kg. per cm.$^2$ or to steam temperatures exceeding 218° C., and boiler blow down fittings, are to be made of steel or other approved material.

#### Safety Valves

**405** Boilers and unfired steam generators are to be fitted with not less than two safety valves, each having a minimum diameter of 38 mm., but those having a total heating surface of less than 9,3m.$^2$ may have one valve not less than 50 mm. diameter.

**406** The valves, spindles, springs and compression screws are to be so encased and locked that the safety valves and pilot valves, after setting to the working pressure, cannot be tampered with or overloaded in service; the spring casing of superheater safety valves should be ventilated or other arrangement provided to protect the springs from excessive temperature.

Valves are to be so designed that in the event of fracture of springs they cannot lift out of their seats. For safety valves operating at pressures below 17,6 kg. per cm.$^2$ it should, in general, be possible for the valves to be turned round on their seats by hand.

Easing gear is to be provided for lifting the safety valves and is to be operable by mechanical means at a safe position from the boiler or engine room platforms.

Safety valves are to be made with working parts having ample clearances to ensure complete freedom of movement. Valve seats are to be effectively secured in position. Any adjusting devices which control discharge capacity are to be positively secured so that the adjustment will not be affected when the safety valves are dismantled at surveys.

**407** All the safety valves of each boiler and unfired steam generator may be fitted in one chest, which is to be separate from any other valve chest and is to be connected

directly to the shell by a strong and stiff neck, the passage through which is to be of not less cross sectional area than the aggregate area of the safety valves in the chest in the case of full lift valves and one-half of that area in the case of other valves. For meaning of aggregate area *see* 408.

Each safety valve chest is to be drained by a pipe fitted to the lowest part and led with a continuous fall to the bilge or to a tank, clear of the boilers. No cocks or valves are to be fitted to these drain pipes. It is recommended that the bore of the drain pipes be not less than 19 mm.

SATURATED STEAM

**408** The minimum aggregate area of the orifices through the seatings of the safety valves on each boiler and unfired steam generator is to be found by the following formula:—

$$A = \frac{E \times C}{p + 1{,}05}$$

where A = *for ordinary, high lift or improved high lift safety valves*, the aggregate area in mm.$^2$ of the orifices through the seatings of the valves, neglecting the area of guides and other obstructions,

= *for full lift safety valves*, the net aggregate area in mm.$^2$ through the seats after deducting the area of the guides or other obstructions when the valves are fully lifted,

p = working pressure, in kg. per cm.$^2$ gauge,

E = designed evaporation, in kg. per hour. In no case shall the designed evaporation be based on less than 29 kg. per m.$^2$ of heating surface per hour for coal or oil fired boilers and 14,5 kg. per m.$^2$ per hour for exhaust gas heated boilers.

C = 21 for valves of ordinary type having a minimum lift of D/24,
14 for valves of high lift type, having a minimum lift of D/16,
10,5 for valves of improved high lift type having a minimum lift of D/12,
5,25 for valves of full lift type having a minimum lift of D/4,

D = bore of valve seat, in millimetres.

When the discharge capacity of a safety valve of approved design has been established by type tests, carried out in the presence of the Surveyors or by an independent authority recognised by the Society, on valves representative of the range of sizes and pressures intended for marine application, consideration will be given to the use of a lower constant than C=5,25 based on 90 per cent of the measured capacity down to a minimum of C=2,24 for full lift safety valves.

SUPERHEATED STEAM

**409** For valves which have to pass superheated steam, the aggregate area of the valves is to be the area A required by 408, multiplied by the factor:—

$$(1 + 0{,}0018T)$$

where T = degree of superheat, in degrees Centigrade.

### Unfired Steam Generators

**410** Steam heated steam generators are to be protected from excessive pressure resulting from any failure of the high pressure heating tubes. For this purpose, the area of safety valves obtained by the formula in 408 may require to be increased unless other protective devices are provided to control the supply of steam to the heating tubes.

### Waste Steam Pipe

**411** For ordinary, high lift and improved high lift type valves, the cross-sectional area of the waste steam pipe and passages leading to it, is to be at least 10 per cent greater than the aggregate area of the safety valves as calculated by the foregoing formulæ. For other valves the cross-sectional area of the waste steam pipe and passages is to be not less than $\frac{10}{C}$ times the aggregate valve area.

The cross-sectional area of the main waste steam pipe is to be not less than the combined cross-sectional areas of the branch waste steam pipes leading thereto from the boiler safety valves.

Waste steam pipes from boilers and unfired steam generators are to be led to the atmosphere and are to be adequately supported and provided with suitable expansion joints, bends or other means to relieve the safety valve chests of undue loading.

The scantlings of waste steam pipes and silencers are to be suitable for the maximum pressure to which the pipes may be subjected in service and not less than $\frac{1}{4}$ of the pressure to which the valves are to be set.

Silencers fitted to waste steam pipes are to be so designed that the clear area through the baffle plates is not less than that required for the pipes.

The safety valves of each exhaust gas heated economiser and each exhaust gas heated boiler which may be used as an economiser are to be provided with entirely separate waste steam pipes.

External drains and exhaust steam vents to atmosphere are not to be led to waste steam pipes.

It is recommended that a scale trap and means for cleaning be provided at the base of each waste steam pipe to the Surveyors' satisfaction.

### Accumulation Tests

**412** All safety valves are to be set under steam to a pressure not greater than 3 per cent above the approved working pressure of the boiler. During a test of 15 minutes with the stop valves closed and under full firing conditions the accumulation of pressure is not to exceed 10 per cent of the loaded pressure. During this test no more feed water should be supplied than is necessary to maintain a safe-working water level.

**413** For accumulation tests on the safety valves of water tube boilers, *see* J 1703 and J 1704.

### Stop Valves

**414** One main stop valve is to be fitted to each boiler secured direct to the shell. There are to be as few auxiliary stop valves as possible so as to avoid piercing the boiler shell more than is absolutely necessary. The arrangement, however, is to be such that where more than one boiler is fitted it is possible to supply the steam whistle, the steam steering gear, and the electric light machinery from at least two boilers.

### Water Level Indicators on Cylindrical Boilers

**415** Every boiler is to be fitted with at least two independent means of indicating the water level in it, one of which is to be a glass gauge. The other means is to be either an additional glass gauge or an approved equivalent device.

On double-ended boilers the above two water level indicators are to be fitted at each end, one indicator being positioned on each side.

On single-ended boilers, the water level indicators are also to be fitted one on each side of the boiler.

**416** A set of not less than two test cocks will be accepted as the approved equivalent device mentioned in 415, for boilers having a working pressure less than 8,4 kg. per cm.$^2$ or an internal diameter less than 1,83 metres.

The test cocks are to be fitted, where practicable, direct to the boiler plating.

**417** The water gauges are to be readily accessible and placed so that the water level is clearly visible.

The lowest visible part of the glass of the water gauge and the lower test cock, where test cocks are fitted, are to be situated at the lowest safe working water level.

**418** The level of the highest part of the effective heating surfaces, e.g., combustion chamber top of a horizontal boiler and the furnace crown of a vertical boiler, is to be clearly marked in a position adjacent to the glass water gauge.

**419** The cocks of all water gauges are to be accessible from positions free from danger in the event of the glass breaking.

**420** If the water gauges are not fitted directly to the shell of the boiler but to stand pillars or columns, it is desirable that these pillars or columns should be bolted directly to the shell of the boiler. If they are connected to the boiler by means of pipes the pipes are to be fitted with terminal cocks, not valves, secured direct to the boiler shell. For boilers exceeding 3 metres in diameter the pillars are to be not less than 63 mm. and the connecting pipes not less than 38 mm. internal diameter. For boilers exceeding 2,30 metres but not exceeding 3 metres in diameter the pillars are to be not less than 50 mm. and the pipes not less than 32 mm. internal diameter, and for boilers 2,30 metres in diameter and under the pillars are to be not less than 45 mm. and the pipes not less than 25 mm. internal diameter. The upper ends of the connecting pipes are to be so arranged that there is no pocket or bend where an accumulation of water from the condensation of the steam can lodge. They should not pass through the uptake if they can be otherwise arranged. If, however, this condition cannot be complied with, they may pass through it by means of a passage at least 50 mm. clear of the pipe all round, open for ventilation.

**421** For water level indicators on water tube boilers, *see* J 1706 and J 1707.

### Feed Check Valves

**422** Two feed check valves, connected to separate feed lines, are to be provided for all main, auxiliary and donkey boilers which are required for essential services with the exception of boilers in which steam is generated exclusively by exhaust gas or steam, where one feed check valve will be accepted. (*See* E 701.)

The feed check valves are to be attached, wherever practicable, direct to the boiler but where the arrangements necessitate the use of standpipes between the boiler and the check valves, these pipes are to be of steel or other approved material.

**423** For boiler feed water systems, *see* E 7, and for feed water fittings on water tube boilers, *see* J 1708 and J 1709.

### Pressure Gauges

**424** Each boiler is to be provided with a separate steam pressure gauge. Double-ended boilers are to be provided with a pressure gauge at each end. The gauges are to be placed where they are easily seen.

### Blow-down and Scum Valves

**425** Each boiler is to be fitted with at least one blow-down valve secured direct to the lower part of the boiler.

Where it is not practicable to attach the blow-down valve direct to water tube boilers, the valve may be placed immediately outside the boiler casing with a steel pipe of substantial thickness fitted between the boiler and valve. The pipe and valve are to be suitably supported and any pipe which may be exposed to direct heat from the furnace is to be adequately protected.

The blow-down valve and its connections to the sea need not be more than 38 mm. and is to be not less than 20 mm. in diameter. For cylindrical boilers the size of the valve may be generally 8,5 mm. in diameter for each metre in diameter of the boiler.

Vertical boilers are to be fitted with a blow-down valve or cock.

**426** Blow-down valves and scum valves (where these latter are fitted) of two or more boilers may be connected to one common discharge, but where thus arranged there are to be screw-down non-return valves fitted for each boiler to prevent the possibility of the contents of one boiler passing to another.

For blow-down cock or valve on ship's side and attachments, *see* E 267 and E 268.

### Salinometer Cock or Valve

**427** Each boiler is to be provided with a salinometer cock or valve secured direct to the boiler in a convenient position. The cock or valve is not to be on the water gauge standpipe.

## Section 5

### RIVETED CYLINDRICAL SHELLS

**501** For the cylindrical shells of steel marine boilers the maximum working pressure is to be calculated from the following formula:—

$$WP = \frac{(t-1{,}6) \times S \times J}{1{,}92 \times D}$$

where WP = maximum working pressure in kg. per cm.$^2$,

t = thickness of the shell plates, in millimetres,

S = minimum tensile strength of the steel shell plates, in kg. per mm.$^2$,

J = percentage of strength of the longitudinal seams, with double butt straps, calculated by the methods described in 502,

D = inside diameter of the outer strake of plating of the cylindrical shell, measured in millimetres.

**502** The percentage of strength of a riveted joint (J) is found from the following formulæ, the first two being applicable to any type of joint, and the third to that type of joint in which the number of rivets in the inner rows is double that in the outer row. The lowest value given by the application of these formulæ is to be taken as the percentage of strength of the joint.

$$\left.\begin{array}{l}\text{Percentage of strength of plate at}\\ \text{joint as compared with solid plate}\end{array}\right\} = \frac{100\,(p-d)}{p}$$

$$\left.\begin{array}{l}\text{Percentage of strength}\\ \text{of rivets as compared}\\ \text{with solid plate}\end{array}\right\} = \frac{100\,(S_2 \times a \times n \times C)}{S_1 \times p \times T}$$

Percentage of combined strength of the plate at the inner row of rivet holes and of the rivets in the outer row

$$= \frac{100\,(p-2d)}{p} + \frac{100\,(S_2 \times a \times C)}{S_1 \times p \times T}$$

Where p = pitch of rivets at outer rows, in millimetres,

d = diameter of rivet holes, in millimetres,

a = sectional area of one rivet, in mm.$^2$,

n = number of rivets which are fitted in the pitch p,

T = thickness of plate, in millimetres,

$S_1$ = minimum tensile strength of plates, in kg. per mm.$^2$,

$S_2$ = shearing strength of rivets, which is taken generally to be 36 kg. per mm.$^2$, and may be 85 per cent of the minimum tensile strength of the rivet bars,

C = 1,0 for rivets in single shear as in lap circumferential joints, 1,875 for rivets in double shear as in double butt-strapped longitudinal joints.

**503** All longitudinal seams are to be butt jointed with double butt straps; the outer butt strap is to be at least 0,625 of the strength of the plate and of sufficient thickness to permit of efficient caulking of its outer edges. The inner butt strap is to be 3 mm. thicker than this.

In cases where the number of rivets in the inner rows is double the number in the outer row, this will require the

minimum thickness, in millimetres, of the outer strap ($t_o$) to be

$$t_o = \frac{5 \times (p-d)}{8 \times (p-2d)} \times T$$

and that of the inner strap ($t_n$) to be

$$t_n = \left\{ \frac{5 \times (p-d)}{8 \times (p-2d)} \times T \right\} + 3 \text{ mm.}$$

**504** In all cases the clear space between a rivet hole and the edge of a plate is to be not less than the diameter of the rivet holes, i.e., the centre of the rivet hole is to be at least 1,5 diameters distant from the edge of the plate.

In the joints whether lapped or fitted with butt straps, in which there are more than one row of rivets and in which there is an equal number of rivets in each row, the distance between the rows of rivets is to be not less than $0{,}33\ p + 0{,}67\ d$ with zigzag riveting, or $2\ d$ with chain riveting.

In joints in which the number of rivets in the outer rows is one half of the number in each of the inner rows, and in which the inner rows are chain riveted, the distance between the outer rows and the next rows is to be not less than $0{,}33\ p + 0{,}67\ d$ or $2\ d$, whichever is the greater, and the distance between the rows in which there are the full number of rivets is to be not less than $2\ d$.

In joints in which the number of rivets in the outer rows is one-half of the number in each of the inner rows and in which the inner rows are zigzag, the distance between the outer rows and the next rows is to be not less than $0{,}2\ p + 1{,}15\ d$, and the distance between the rows in which there are the full number of rivets is to be not less than $0{,}165\ p + 0{,}67\ d$.

In the above $p$ is the pitch of the rivets in the outer rows.

**505** The maximum pitch, in millimetres, of the rivets in the longitudinal seams, with double butt straps, of boiler shells

$$= (C \times T) + 40 \text{ mm,}$$

where $T$ is the thickness of the plate in millimetres and $C$ is a coefficient as given in the following Table:—

| Number of rivets per pitch | Coefficients C |
|---|---|
| 1 | 1,75 |
| 2 | 3,50 |
| 3 | 4,63 |
| 4 | 5,52 |
| 5 | 6,00 |

**506** If holes are cut in the cylindrical shells of boilers for fixing of mountings, the diameters of the holes being greater than 2,5 times the thickness of the shell plating plus 70 mm., compensation is to be fitted as in the case of manholes. (*See* J 201.)

**507** Where more than three screw stays pierce the cylindrical shell in a horizontal line, if $d$ is their diameter and $p$ the pitch, $\frac{100\ (p-d)}{p}$ should not be less than the percentage of strength required for the shell longitudinal joints. If this is not possible, stays are to be arranged out of line with one another longitudinally.

**508** The strength of the seams joining the end plates to the cylindrical shell is not to be less than 42 per cent of that of the solid shell plate. Where the shell plates exceed 16 mm. in thickness the seams connecting the shell plates to the end plates are to be at least double riveted. Where the shell plates exceed 13 mm. in thickness the intermediate circumferential seams of double-ended boilers are to be at least double riveted.

**509** The circumferential seam at or near the middle of the length of single-ended boilers is to have a strength of joint not less than 60 per cent of the solid plate. The inner circumferential seams of double-ended boilers are to have a strength of joint not less than 62 per cent of the solid plate. In any case there are to be at least three rows of rivets where single-ended boilers have shell plates over 35 mm. in thickness and where double-ended boilers have shell plates over 30 mm. in thickness.

**510** The circumferential seams of the shells of vertical boilers are to have a strength of not less than 42 per cent of the solid plate. Where these seams are not complete circles, and where the shell plates exceed 16 mm. in thickness, the riveting is to be at least double.

## Section 6

### FURNACES

*Note:—Furnaces, plain or corrugated, are not to exceed 21 mm. in thickness.*

#### Corrugated Furnaces

**601** The working pressure to be allowed on corrugated furnaces is to be determined by the following formula:—

$$WP = \frac{C\ (t-0{,}8)}{D}$$

where $WP$ = working pressure, in kg. per cm.$^2$,
$D$ = external diameter measured at the bottom of the corrugations, in millimetres,
$t$ = thickness of the furnace plate, in millimetres, measured at the bottom of the corrugations or camber,

C = 1080 for the Fox, Morison, Deighton, Purves and other similar furnaces, 1150 for the Leeds Forge Bulb Suspension furnace.

### Plain Furnaces and Combustion Chamber Bottoms

**602** The working pressure to be allowed on plain furnaces or furnaces strengthened by the Adamson or other joints, and on the cylindrical bottoms of combustion chambers, is to be determined by the following formulæ, the least pressure obtained by either formula being taken:—

$$WP = \frac{C\,(t-0{,}8)^2}{(L + 610) \times D}$$

$$\text{or } WP = \frac{C_1}{D} \times [320\,(t-0{,}8) - L]$$

where WP = working pressure, in kg. per cm.$^2$,
D = external diameter of the furnace or combustion chamber, in millimetres,
t = thickness of the plate, in millimetres,
L = length of the furnace or of combustion chamber bottom or the length between points of substantial support, in millimetres, measured from the centres of the rivet rows or from the commencement of flange curvature, whichever is applicable,
C = 104400 where the longitudinal seams are welded and 93600 where they are riveted,
$C_1$ = 3,5 where the longitudinal seams are welded and 3,16 where they are riveted.

**603** Where the furnaces are tapered, the diameter to be taken for calculation purposes is to be the mean of that at the top and of that at the bottom where it meets the substantial support from flange or ring. The length for the same purpose is to be the distance from the centre of the row of rivets connecting the crown to the body of the furnace, to the substantial support at the bottom of the furnace or to a row of screwed stays connecting the furnace to the shell, provided the pitch of stays at the furnace does not exceed 14 times the thickness of the furnace plate where the stays are riveted at their ends, and 16 times where they are fitted with nuts. Such screwed stays are to be in diameter over the threads not less than 2,25 times the thickness of the furnace plate.

### Furnaces of Spherical Form

**604** Where the furnaces are spherical in form and convex upwards at their tops, and are without support from stays of any kind:—

$$WP = \frac{620\,(t - 0{,}8)}{R}$$

where WP = working pressure, in kg. per cm.$^2$,
t = thickness of the top plate, in millimetres,
R = outer radius of curvature of the furnace, in millimetres.

### Uptakes of Vertical Boilers

**605** The working pressure to be allowed on internal uptakes of vertical boilers is to be determined by the following formulæ, the least pressure obtained by either formula being taken:—

$$WP = \frac{C\,(t - 4)^2}{(L + 610) \times D}$$

$$\text{or } WP = \frac{C_1}{D} \times [320\,(t - 4) - L]$$

where WP = working pressure, in kg. per cm.$^2$,
D = external diameter of the uptake, in millimetres,
t = thickness of the uptake, in millimetres,
L = length of the uptake between points of substantial support, in millimetres, measured from the centres of the rivet rows,
C = 104400 where the longitudinal seams are welded and 93600 where they are riveted,
$C_1$ = 3,5 where the longitudinal seams are welded and 3,16 where they are riveted.

### Cross Tubes

**606** The thickness of cross tubes in cross tube boilers is to be determined from the following formula, but is in no case to be less than 9,5 mm.:—

$$t = \frac{WP \times D}{450} + 5{,}6$$

where WP = working pressure, in kg. per cm.$^2$,
t = minimum thickness, in millimetres,
D = internal diameter of the cross tube, in millimetres.

### Ogee Rings

**607** For the ogee ring which connects the bottom of the furnace to the shell, and sustains the whole load on the furnace vertically:—

$$WP = \frac{10100\,(t-0{,}8)^2}{D \times (D - d)}$$

where WP = working pressure, in kg. per cm.$^2$,
t = thickness of the ogee ring, in millimetres,
D = inside diameter of the boiler shell, in millimetres,
d = outside diameter of the lower part of the furnace where it joins the ogee ring, in millimetres.

## Section 7

## FLAT PLATES SUPPORTED BY STAYS SECURED IN VARIOUS WAYS

**701** The working pressure to be allowed on flat plates supported by stays is to be calculated by the following formula:—

$$WP = \frac{(t - 0{,}8)^2 \times C}{a^2 + b^2}$$

In this formula and in the formulæ in 708 to 711

WP = working pressure, in kg. per cm.2,
t = thickness of the flat plate, in millimetres,
$t_w$ = thickness of the washers, strips, or doublings employed, in millimetres,
a = distance apart of the rows of stays, in millimetres,
b = pitch of the stays in the rows, in millimetres,
C is a coefficient which varies with the method of fixing the stays as follows:—

Where the plates are exposed to flame and the stays are screwed into the plate and their ends are riveted over C = 3600. Where the plates are not exposed to flame and the stays are screwed into the plate and their ends are riveted over C = 4100. In these cases the thickness of the plate is to be at least half the diameter of the stay required by the Rules.

Where stay tubes are screwed into tube plates and expanded C = 3740. If they are fitted with nuts C = 5180.

Where the plates are exposed to flame and the stays are screwed into the plate and fitted with nuts on the outside C = 5400. Where the plates are not exposed to flame C = 6200.

Where the stays pass through the plates not exposed to flame and are fitted with nuts inside and outside C = 6900, and where the plates are exposed to flame C = 6050.

**702** Where plates are stiffened by flanging, the inner radius of which is not greater than 2,5 times the thickness of the plate, for the support thus given C = 7900 where the plates are not exposed to flame and C = 6900 where they are exposed to flame. The pitch is to be reckoned from the commencement of the curvature.

**703** For portions of plate where the stays are irregularly pitched $d^2$ is to be used instead of $a^2 + b^2$, d being the diameter of the largest circle which can be drawn passing through not less than three points of support, i.e., the centres of stays or the commencement of the curvature of flanging whichever is applicable. In this case C is to be taken as the mean of the values appropriate for the points of support.

**704** For the tops and sides of combustion chambers the distance between the rows of stays nearest to the back tube plate or the back plate respectively and the commencement of curvature of these plates at their flanges is to be not greater than a.

**705** The stays of the combustion chambers are to be so placed that the seams of the plates can be caulked without removing the stay nuts.

**706** For the tops of combustion chambers where they are joined to the sides by curved portions, if the outer radius of the curved portion is less than half the allowable distance between the girders, the distance between the first girder and the inner surface of the side plate is not to exceed the allowable distance between the girders. If the radius of the curved portion is greater than half the allowable distance between the girders, the width of the flat portion measured from the centre of the girder is to be not more than half the allowable distance between the girders.

**707** Where portions of plate are supported by stays secured in different ways the value of C to be taken is the mean of the values appropriate to the method of securing the supporting stays.

**708** Where the plate is supported by stays which pass through it and are fitted with nuts inside and washers and nuts outside, the diameter of the washers being at least 3,5 times that of the stay, and their thickness at least two-thirds of that of the plate but not greater than that of the plate:—

$$WP = \frac{7200}{a^2 + b^2} [(t - 0{,}8)^2 + 0{,}15\ t_w^2]$$

**709** Where the washers have a diameter of at least two-thirds of the pitch of the stays and a thickness of at least two-thirds of the thickness of the plate but not greater than that of the plate and are riveted to the plate in an efficient manner:—

$$WP = \frac{7200}{a^2 + b^2} [(t - 0{,}8)^2 + 0{,}35\ t_w^2]$$

**710** Where the plate is stiffened by strips at least two-thirds of the pitch of the stays in breadth and having a thickness at least two-thirds of that of the plate but not greater than that of the plate and which are riveted to the plate in an efficient manner:—

$$WP = \frac{7200}{a^2 + b^2} [(t - 0{,}8)^2 + 0{,}55\ t_w^2]$$

**711** Where the plate is fitted with doubling plates having a thickness of at least two-thirds of that of the plate but not greater than that of the plate and which are riveted to the plate in an efficient manner:—

$$WP = \frac{7200}{a^2 + b^2} [(t - 0{,}8)^2 + 0{,}85\ t_w^2]$$

**712** For the portions of tube plates in the nests of tubes:—

$$WP = \frac{C\,(t - 0{,}8)^2}{p^2}$$

where WP = working pressure, in kg. per cm.$^2$,
t = thickness of the tube plate, in millimetres,
p = mean pitch, in millimetres, of the stay tubes supporting any portions of the plate (being the sum of the four sides of the quadrilateral divided by 4),
C = 2740 where the stay tubes are screwed and expanded into the plate and nuts are not fitted,
3530 where the stay tubes are screwed and expanded into the plate and fitted with nuts. (*See* J 1206.)

**713** For the wide water spaces of front tube plates between the nests of tubes and between the wing rows of tubes and the shell:—

$$WP = \frac{C[(t - 0{,}8)^2 + 0{,}55\ t_w{}^2]}{a^2 + b^2}$$

where WP = working pressure, in kg. per cm.$^2$,
t = thickness of the front tube plate, in millimetres,
$t_w$ = thickness of the doubling plate, where so fitted, in millimetres,
a = horizontal pitch of stay tubes, in millimetres, measured across the wide water space,
b = vertical pitch of stay tubes in the bounding rows, in millimetres, measured from centre to centre,
C = 3740 where the stay tubes are screwed and expanded into the tube plate and nuts are not fitted,
5180 where the stay tubes are screwed and expanded into the tube plate, and nuts are fitted to each stay tube,
4540 where the stay tubes are screwed and expanded into the tube plate, and nuts are fitted only to alternate stay tubes.

**714** If steel of less strength than 41 kg. per mm.2 is used for flat plates, the working pressure allowed is to be correspondingly reduced.

## Section 8

### TUBE PLATES UNDER COMPRESSION

**801** The pressure to be allowed on tube plates is to be calculated by the following formula, in which the compressive stress is taken at 9,8 kg. per mm.$^2$:—

$$WP = 1970 \times \frac{(D - d) \times t}{W \times D}$$

where WP = working pressure, in kg. per cm.2,
t = thickness of the tube plate, in millimetres,
D = horizontal distance apart of the tubes centre to centre, in millimetres,
d = internal diameter of the plain tubes, in millimetres,
W = width of combustion chamber, in millimetres, measured inside from tube plate to back chamber plate, or between tube plates in double-ended boilers with combustion chambers common to two opposite furnaces.

## Section 9

### TUBE PLATES OF VERTICAL BOILERS

**901** Where vertical boilers have a nest or nests of horizontal tubes so that there is direct tension on the tube plates due to the vertical load on the boiler ends or to their acting as horizontal ties across the shell, the thickness of the tube plates and the spacing of the tubes are to be such that the section of metal taking the load is sufficient to keep the stress within that allowed on the shell plates.

**902** Each alternate tube in the outer vertical rows of tubes is to be a stay tube. The tube plates between the stay tubes are to be in accordance with J 712 and in addition:—

$$WP = \frac{(t - 1{,}6) \times S \times (p - d) \times 100}{2{,}03 \times D \times p}$$

where WP = working pressure, in kg. per cm.$^2$,
S = minimum tensile strength of the steel plate, in kg. per mm.$^2$,
t = thickness of the tube plate, in millimetres,
D = twice the radial distance of the centre of the outer row of tube holes from the axis of the shell, in millimetres,
p = vertical pitch of tubes, in millimetres,
d = diameter of the tube holes, in millimetres.

The least working pressure obtained by the above formula and that in J 712 is to be taken.

## Section 10

### GIRDERS

**1001** For girders supporting the tops of combustion chambers the following formula is to be used:—

$$WP = \frac{C \times d^2 \times t}{(L - P) \times D \times L} \times \frac{S}{44}$$

where WP = working pressure, in kg. per cm.$^2$,
d = depth of the girder at centre, in millimetres,
t = thickness of the girder at centre, where this is a forging, or the sum of the thicknesses of the plates where the girder is made of two plates, measured in millimetres,
L = length of the girder, in millimetres, measured between the tube plate and back chamber plate inside, or between tube plates in chambers common to two opposite furnaces,
P = pitch of stays supported by the girder, in millimetres,
D = distance apart of the girders, centre to centre, in millimetres,
S = minimum tensile strength of the material forming the girder, in kg. per mm.$^2$,

$$C = \frac{n}{n+1} \times 1100,$$ where the number of stays (n) in each girder is odd,

$$\frac{n+1}{n+2} \times 1100,$$ where the number of stays (n) in each girder is even.

## Section 11

### STAYS

#### Screw Stays

**1101** For steel screw stays with threads not coarser than 9 threads per 25,4 mm., the following formula is to be used, but in no case is the stress to exceed 6,33 kg. per mm.$^2$:—

$$WP = \frac{(d - 6{,}8)^2 \times 580}{a}$$

where WP = working pressure, in kg. per cm.$^2$,
d = diameter of the stay over the thread, in millimetres,
a = area, in square millimetres, supported by one stay.

#### Longitudinal Stays

**1102** For steel longitudinal stays with threads not coarser than 6 threads per 25,4 mm. the working pressure is to be calculated from the following formula, but in no case is the stress to exceed

$$\frac{\text{Minimum Tensile Strength, in kg. per mm.}^2}{5{,}7}$$

$$WP = \frac{(d - 8{,}6)^2 \times 670}{a} \times \frac{S}{44}$$

where WP = working pressure, in kg. per cm.$^2$,
d = diameter of the stay over the thread, in millimetres,
a = area, in square millimetres, supported by one stay,
S = minimum tensile strength of the steel, in kg. per mm.$^2$

**1103** In cases where longitudinal stays are made with enlarged ends and the body of the stay is smaller in diameter than at the bottom of the thread, and in cases where coarser threads than 6 per 25,4 mm. are used, the working pressure is to be calculated from the following formula:—

$$WP = \frac{(d^1 - 3{,}2)^2 \times 670}{a} \times \frac{S}{44}$$

$d^1$ = diameter of the stay at the bottom of the thread or at the smallest part of the body.

Other symbols as defined in 1102.

#### Cross-reference

**1104** *See* also requirements of J 108 to J 112.

## Section 12

### BOILER TUBES, PLAIN AND STAY, AND SUPERHEATER TUBES

**1201** Where tubes are made of steel, the material is to comply with the relevant requirements of P 9.

**1202** The following table gives the working pressures permissible with plain boiler tubes of standard thicknesses, whether of lapwelded wrought iron or of lapwelded or seamless mild steel:—

| Outside diameter of tube in millimetres | Standard thicknesses in millimetres | | | | Working pressures in kg. per cm.$^2$ | | | |
|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | A | B | C | D |
| 51 | | 3,00 | 3,25 | 3,65 | | 11 | 15 | 21 |
| 57 | 3,00 | 3,25 | 3,65 | 4,00 | 10 | 13,5 | 18 | 23 |
| 63,5 | 3,00 | 3,25 | 3,65 | 4,00 | 9 | 12,5 | 16 | 21 |
| 70 | 3,00 | 3,25 | 3,65 | 4,00 | 8 | 11 | 15 | 19,5 |
| 76 | 3,25 | 3,65 | 4,00 | 4,5 | 10 | 13,5 | 17,5 | 21 |
| 82,5 | 3,25 | 3,65 | 4,00 | 4,5 | 9 | 12,5 | 16 | 19,5 |
| 89 | 3,25 | 3,65 | 4,00 | 4,5 | 8,5 | 11,5 | 15 | 18 |

**1203** On stay tubes, whether of wrought iron or of steel, a working stress of 5,27 kg. per mm$^2$. of the net sectional area at the bottom of the thread is allowed.

**1204** The minimum thickness of stay tubes measured under the threads is to be 6 mm. for marginal stay tubes and 5 mm. for other stay tubes.

**1205** Stay tubes are to be screwed at both ends with continuous threads, and the holes in the tube plates are to be tapped with continuous threads. The pitch of the thread is to be not finer than 10 threads per 25,4 mm. It is desirable however that they should be screwed to the standard 9 threads per 25,4 mm. The stay tubes are to be expanded by roller expanders and not made tight by caulking only.

**1206** Nuts are not to be fitted to stay tubes at the combustion chamber end.

**1207** If stay tubes are increased in thickness at the screwed ends so that the thickness at the bottom of thread is practically the same as in the body of the tube, the thickening is to be attained by upsetting and not by any welding process, and the tubes are to be annealed after the upsetting.

### Tubes for Superheaters attached to Cylindrical Boilers

**1208** The minimum thickness of the tubes is to be calculated by the following formula:—

$$t = \frac{WP \times d}{530} + 1{,}8$$

where WP = working pressure in the boiler, kg. per cm.$^2$
d = external diameter, in millimetres.
t = thickness, in millimetres.

## Section 13

### DISHED END PLATES WITHOUT STAYS

**1301** For ends of boiler drums and receivers, crowns of vertical boilers and other similar plates dished to partially spherical form subject to pressure on the concave side, but not exposed to flame, and having no unreinforced opening greater than four times the thickness of the plate, the working pressure to be allowed is to be determined by the following formula or, if desired, by the formula in J 1605 :—

$$WP = \frac{21{,}4 \times S\,(T - 0{,}8)}{R}$$

where WP = working pressure, in kg. per cm.$^2$
T = thickness of the end, in millimetres, after dishing but in no case to be less than the thickness of a seamless unpierced shell of the same diameter and material.
S = minimum tensile strength of the material, in kg. per mm.$^2$
R = inside radius of curvature of end, in millimetres, which is not to exceed the outside diameter of drum end.

The inside corner radius is to be not less than four times the thickness of the end plate and in no case less than 64 mm.

**1302** Proposals to make dished end plates of semi-elliptic form will be considered provided full details are submitted before the work is commenced.

**1303** Where the end is provided with a flanged manhole the thickness of the end in millimetres obtained by the formulæ in 1301 is to be increased by 3 mm. and the depth (F) of the manhole flange, measured in millimetres from the outer surface at the minor axis is to be not less than

$$F = \sqrt{T_1 \times W}$$

where $T_1$ = required thickness of the end plate, in millimetres,
W = minor axis of the manhole, in millimetres.

**1304** Where the end is provided with large openings for branches, mountings, or unflanged manholes the thickness of the end, as determined by the formulæ in 1301, is to be increased by 3 mm. and adequate compensation is to be provided, at least equivalent to the cross sectional area obtained by multiplying the diameter or major axis of the opening cut in the end plate by the thickness required for an equivalent unpierced end.

**1305** Where the end is provided with small openings greater than four times the thickness of the end plate, local compensation is to be provided.

**1306** Where the end or crown is a complete hemisphere without stays or other supports, and is made in more than one plate, the working pressure to be allowed is given by the following formula:—

$$WP = \frac{(t - 1{,}6)\ S \times J}{C \times R}$$

where WP = working pressure, in kg. per cm.$^2$,
t = thickness of the plates, in millimetres,
S = minimum tensile strength of the steel plates, in kg. per mm.$^2$,
J = strength of riveted joint as a percentage of the solid plate,
R = inner radius of curvature, in millimetres
C = 1,98 for treble riveted,
2,03 for double riveted,
2,31 for single riveted.

# WATER TUBE BOILERS

## Section 14

### GENERAL REQUIREMENTS

**1401** In the design and construction of water tube boilers intended for working pressures up to 105 kg. per cm.$^2$ the following conditions are to be observed.

**Materials**

**1402** The materials are to comply with the relevant requirements of Chapter P.

Where it is proposed to use alloy steels for superheater headers or tubes, particulars of the appropriate British or other national standard material specifications with details of the chemical compositions, heat treatment and mechanical properties are to be submitted for consideration.

**1403** Where the material does not conform to an established standard, particulars of the long-term creep and rupture data at the operating temperature are to be submitted in addition to the details required by 1402 for the purpose of assessing a safe working stress.

If the long-term creep data has been estimated, details of the method of estimation are also to be submitted.

Particulars of scaling and corrosion resistance of the material under the operating conditions are to be submitted when required.

**Protection of Drums and Headers**

**1404** Where any parts of the boiler drums or headers are not protected by tubes and are exposed to radiation from the fire, or to the impact of hot gases, they are to be protected by a shield of good refractory materials or by other approved means.

**Access Arrangements**

**1405** Manholes are to be provided in all drums of sufficient size to permit of access for internal examination and cleaning and for fitting and expanding the tubes. In the case of headers for water walls, superheaters or economisers and of drums which are too small to permit entry, sight holes or mudholes sufficiently large and numerous for these purposes are to be provided.

**1406** Doors for manholes, mudholes and sight holes are to be formed from steel plate or of other approved construction and all jointing surfaces are to be machined.

The doors are to be of the internal type and are to be provided with spigots which have a clearance of not more than 1,5 mm. all round, i.e. the axes of the opening are not to exceed those of the door by more than 3 mm.

**1407** Doors for openings not larger than 230 mm. × 180 mm. need only be fitted with one stud which may be forged integral with the door. Larger doors are to be provided with two studs screwed through the door and fitted with nuts on the inside or alternatively, bolts may be used screwed through the door with the heads inside ; other methods of attachment may be accepted provided details are submitted for consideration.

The crossbars or dogs are to be of steel.

For smaller circular openings in headers and similar fittings an approved type of plug may be used.

## Section 15

### CONSTRUCTION OF WATER TUBE BOILERS

**Seamless Drums**

**1501** Seamless forged drums are to be made in accordance with the requirements of P 7.

**Welded and Riveted Drums**

**1502** Drums of welded construction are to be made in accordance with the requirements of J 18 to J 23 in so far as they are applicable.

**1503** Drums of riveted construction are to be made in accordance with the requirements of J 5, which requires that the longitudinal seams are to be butt jointed with double butt straps.

**1504** Drum shell plates are to be of cylindrical form and are to be bent entirely by machine ; local heating and hammering is not to be employed. Where the plate is bent cold to an internal radius of less than 20 times the plate thickness it is to be efficiently heat treated after bending. Drum ends are to be made from one piece of rolled plate.

**1505** All steel plates which are dished, flanged or locally heated are afterwards to be annealed or normalised.

For heat treatment of welded pressure vessels, *see* J 1925 to J 1929. For plates which are hot formed, *see* P 310.

**Thinning of Plates**

**1506** Where the tube plate is thicker than the drum shell plate, the tube plate, in way of the longitudinal and circumferential seams, is to be reduced in thickness by an equal amount on each side of the plate to the same thickness as the shell plate. This reduction in thickness is to be gradual and carried out by machining.

The thinning of dished end plates in way of butt welded joints is also to be carried out by machining but may be made from one side of the plate.

**Tube Holes**

**1507** The tube holes in drums or headers are to be formed in such a way that the tubes can be effectively tightened in them. Where the tube ends are not normal to the tube plates, there is to be a neck or belt of parallel

seating of at least 13 mm. in depth measured in a plane through the axis of the tube at the holes. Where the tubes are practically normal to their plates, this parallel seating is to be not less than 9,5 mm. in depth.

Tube Ends

**1508** Tubes are to be carefully fitted in the tube holes and secured by means of expanding and belling or by other approved methods. Tubes are to project through the neck or belt of parallel seating by at least 6 mm. and where they are secured from drawing out by means of bellmouthing only the included angle of belling is to be not less than 30°.

Hydraulic Tests

**1509** In all new boilers working at pressures up to 7 kg. per cm.$^2$ the hydraulic test is to be twice the approved boiler pressure. For boilers working at pressures greater than 7 kg. per cm.$^2$ the hydraulic test pressure is to be 1,5 times the approved boiler pressure plus 3,5 kg. per cm.$^2$

**1510** All boiler mountings are to be subjected to a hydraulic test of twice the approved boiler pressure with the exception of feed check valves and other mountings connected to the main feed system which are to be tested to 2,5 times the approved boiler pressure, or twice the maximum pressure which can be developed in the feed line in normal service, whichever is the greater.

## Section 16

### SCANTLINGS OF DRUMS, ENDS, HEADERS AND TUBES

Cylindrical Shells

**1601** When plans of water tube boilers are submitted for approval particulars of the safety valves and their disposition on boiler and superheater, together with the estimated pressure drop through the superheater, are to be stated. The pressures proposed for the settings of boiler and superheater safety valves are to be indicated on the boiler plan.

**1602** The thickness of drum shell plates, which are unpierced by tube holes, is to be determined by formula 1. Where, however, the thickness obtained by that formula exceeds 10 per cent of R then formula 2 is to be used. For shells with riveted joints *see* J 5.

$$(1) \qquad t = \frac{WP \times R \times 2}{C \times f} + 1{,}6$$

$$(2) \qquad t = \frac{WP \times R \times 2}{C \times f - WP} + 1{,}6$$

where t = thickness of plate, in millimetres,

WP = maximum working pressure, in kg. per cm.$^2$

R = internal radius of the shell, in millimetres,

C is a coefficient having a value of

2 for seamless shells,

1,9 for fusion welded joints and

1,6 for forge welded joints.

$f$ = nominal stress, in kg. per cm.$^2$

For shells of boiler steam and water drums $f$ is to be taken as 0,27 of the specified minimum tensile strength of the material.

For seamless superheater drums and headers with metal temperatures above 316° C., the nominal stress $f$ is to be taken from Table 1 which gives values for a number of wrought steels of approved composition in common use. Values of $f$ for other steels will receive special consideration, *see* J 1403. When evaluating the stress $f$, the metal temperature is to be taken as not less than the maximum steam temperature plus 28° C. unless the headers are situated outside the boiler casing.

TABLE 1

| MATERIAL | | NOMINAL STRESS IN Kg. PER Cm.$^2$ AT FOLLOWING METAL TEMPERATURES IN °C. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| TYPE OF STEEL | Minimum tensile strength Kg. per mm.$^2$ | 343 | 371 | 399 | 427 | 454 | 482 | 510 | 538 | 566 |
| Carbon and Carbon-Manganese | 38 | 940 | 930 | 845 | 740 | 560 | 420 | — | — | — |
| | 44 | 1100 | 1070 | 940 | 795 | 605 | 420 | — | — | — |
| | 50,5 | 1260 | 1210 | 1040 | 850 | 650 | 420 | — | — | — |
| | 57 | 1420 | 1350 | 1140 | 910 | 675 | 420 | — | — | — |
| ½% Mo. | 41 | 1025 | 1025 | 1025 | 1000 | 940 | 775 | 460 | — | — |
| | 49 | 1225 | 1225 | 1225 | 1165 | 1085 | 845 | 460 | — | — |
| 1% Cr., ½% Mo. | 42,5 | 1060 | 1060 | 1060 | 1040 | 970 | 810 | 550 | 335 | 195 |
| | 49 | 1225 | 1225 | 1225 | 1180 | 1095 | 880 | 560 | 335 | 195 |
| 2¼% Cr. 1% Mo. | 42,5 | 1060 | 1060 | 1060 | 1040 | 970 | 810 | 550 | 420 | 325 |

The temperature limitations indicated in Table 1 are maxima for the types of steel listed but are not necessarily acceptable for all steels of these types.

### Tube Plates

**1603** The thickness of drum tube plates and cylindrical headers which are drilled for tubes is to be determined by the following formula :—

$$t = \frac{WP \times R \times 2}{1{,}8 \times f \times E - WP} + 1{,}6$$

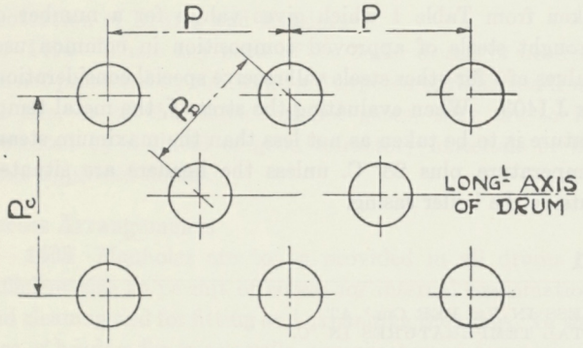
where t, WP and $f$ are as defined in 1602,

R = internal radius of tube plate, in millimetres,

E = efficiency of ligaments between tube holes expressed as a fraction and calculated in accordance with 1604.

### Ligament Efficiency

**1604** Where tube plates or header shells are drilled for tubes the ligament efficiency between tube holes shall be determined by the following methods and the lowest value obtained shall be used in the formula of 1603 for tube plate thickness. Method 2 is only applicable where the tube holes are arranged in lines parallel to the axis so as to form a staggered arrangement with diagonal ligaments.




(1) $$E = \frac{P - d}{P}$$

(2) $$E = \frac{3{,}84 P_D (P_D - 0{,}95d)^2}{(P^2 + 0{,}5 P_C^2)(P_D - 0{,}95d) + P \times P_C \times 0{,}375d}$$

where E = ligament efficiency, expressed as a fraction,

P = longitudinal pitch of tube holes, in millimetres,

$P_C$ = circumferential pitch of tube holes, in millimetres, in line circumferentially measured at the mid-thickness of the plate,

$P_D$ = diagonal pitch of tube holes, in millimetres, measured at the mid-thickness of the plate,

d = mean effective diameter of tube holes, in millimetres.

The circumferential pitch $P_C$ is to be such that the circumferential ligament efficiency is equal to or greater than half the ligament efficiency on the longitudinal axis.

### Dished End Plates

**1605** Where drum ends for boilers and headers are dished from plates and are subject to pressure on the concave side they are to comply with the following :—

(*a*) For ends dished to partial spherical form the inside radius of dishing, R, is to be not greater than the outside diameter D.

The inside corner radius, r, is to be not less than four times the plate thickness and in no case less than 64 mm.

The corner radius at the manhole flange is to be not less than 25 mm.

(*b*) For ends having no unreinforced opening greater than four times the plate thickness, or 64 mm., whichever is less, the working pressure to be allowed is to be determined by the following formula:—

$$WP = \frac{(T - 0{,}8) \times f \times h \times 8{,}4}{D^2} \times \left\{ \frac{\frac{r}{R} + 0{,}05}{\frac{r}{R} + 0{,}15} \right\}$$

where WP = working pressure, in kg. per cm.$^2$,

T = thickness of the end, in millimetres, after dishing which in no case is to be less than the thickness of an unpierced shell of the same diameter and material,

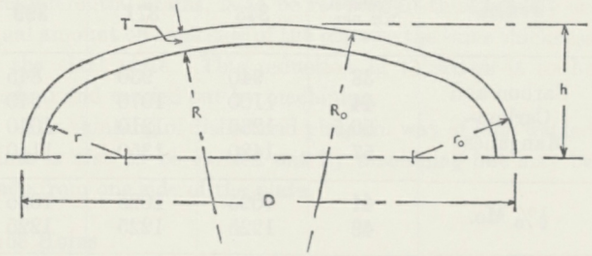
$f$ = nominal stress, in kg. per cm.2, having values as stated in 1602,

D = outside diameter of end, in millimetres,

R = inside radius of dishing, in millimetres,

r = inside radius of corner, in millimetres,

h = external height of dishing, in millimetres measured from the centre of the corner radius, which is to be calculated as follows :—




$$h = R_o - \sqrt{\left(R_o - \frac{D}{2}\right)\left(R_o + \frac{D}{2} - 2r_o\right)}$$

$R_0$ = outside radius of dishing, in millimetres,

$r_0$ = outside radius of corner, in millimetres.

**1606** Proposals to make dished ends of semi-ellipsoidal form will be considered provided details are submitted before the work is commenced.

### Flat End Plates

**1607** For unstayed flat end plates attached by one of the methods shown in J 18, Fig. 2 the working pressure is to be determined by the following formula :—

$$WP = \frac{(T - 0{,}8)^2 \times f \times 7}{D^2}$$

where WP = working pressure, in kg. per cm.$^2$,

T = thickness of plate, in millimetres,

$f$ = nominal stress, in kg. per. cm.$^2$, having values as stated in 1602,

D = inside diameter, in millimetres.

### Compensation for Openings

**1608** Where a dished end is provided with large openings for branches, mountings or unflanged manholes, the thickness of the end as determined by the formula in 1605 is to be increased by 3 mm. and adequate compensation is to be provided at least equivalent to the cross-sectional area obtained by multiplying the diameter or major axis of the opening cut in the end plate by the thickness required for an equivalent unpierced end.

**1609** Where a dished end is provided with a flanged manhole the thickness of the end obtained by the formula in 1605 is to be increased by at least 15% but in no case less than 3 mm. and the depth of the manhole flange is to be determined as follows :—

$$F = \sqrt{T_1 \times W}$$

where F = depth of manhole flange, in millimetres, measured from the outer surface at the minor axis,

$T_1$ = required thickness of end plate, in millimetres,

W = minor axis of manhole, in millimetres.

**1610** In the case of flat plates, the depth of the manhole flange measured from the outer surface is to be not less than $\sqrt{T \times W}$, where T is the thickness of the plate in millimetres and W is the minor axis of the hole in millimetres.

**1611** Manholes in cylindrical shells are to have their shorter axes arranged longitudinally, and are to be located clear of the welded joints in the shell. Where the cylindrical shell is cut for a manhole, compensation is to be provided in accordance with 1612.

**1612** Compensation is to be provided for all openings in shell plates if the diameters of such openings exceed 2,5 times the thickness of the shell plus 70 mm. or $\frac{D}{6}$ whichever is less, where D is the internal diameter of the cylindrical shell in millimetres.

The compensation provided is to be sufficient to ensure that the strength in way of the opening is not less than that of a seamless shell. For thickness of seamless shells *see* formula of 1602.

The width of reinforcing rings allowable for compensation is to be taken as $\sqrt{D \times T}$ or $\frac{D}{2}$ whichever is less, where D is the diameter of the opening in millimetres and T is the shell plate thickness in millimetres. If the surplus thickness of shell plate above that required for a seamless shell is included as compensation, the width allowable for this purpose is the same as that for compensating rings.

Where standpipes are welded to the shell the surplus thickness of the standpipe above that required to withstand the internal pressure may be included as compensation for a distance of $\sqrt{d \times t}$ from the plate surfaces where d and t in millimetres are the internal diameter and wall thickness of the standpipe respectively. The surplus thickness is to be taken as the difference in thickness proposed for the standpipes and that required by E 512 for a steampipe of the same bore and material.

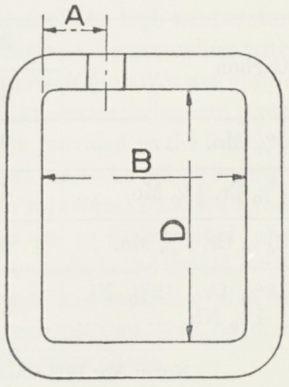
The sectional area of welds which attach compensating rings and standpipes to cylindrical shells may be included as compensation.

### Headers of Rectangular Section

**1613** The working pressure to be allowed for solid drawn and forged headers of rectangular section is to be determined by the following formulæ (1) and (2) whichever gives the lower pressure :—

(1) $$WP = \frac{4 \times f}{\left(\frac{B}{t}\right)^2 + \frac{D}{t}}$$

(2) $$WP = \frac{2 \times f \times E}{K \times \left(\frac{B}{t}\right)^2 + \frac{D}{2 \times t}}$$



where WP = maximum working pressure, in kg. per cm.$^2$,

$f$ = nominal stress, in kg. per cm.$^2$, having values as stated in 1602,

t = wall thickness, in millimetres, minus 1,5 mm.,

B = internal length, in millimetres, of the side under consideration,

D = internal length, in millimetres, of supporting side at right angles to dimension B,

E = minimum longitudinal efficiency of ligament between tube holes or hand holes, expressed as a fraction,

K is a coefficient having values dependent on the ratio of $\frac{A}{B}$ and is to be calculated as follows :—

$$K = 3\left[\frac{A}{B} - \left(\frac{A}{B}\right)^2 - \frac{1}{6}\right]$$

NOTE.— K as calculated may be $\pm$ but the numerical value only is to be taken for use in formula 2.

A = distance between centre line of tube holes or hand holes and the nearest supporting side, in millimetres ; where there are more than one row of tube holes in the length B, the value of A which gives a maximum K is to be selected.

Cross-reference

**1614** For details of hand holes and doors, *see* J 1405 to J 1407.

For details of tube holes and fitting of tubes, *see* J 1507 and J 1508.

Tubes

**1615** The minimum thickness of tubes is to be determined by the following formulæ :—

For all boiler and economiser tubes :

$$t = \frac{WP \times d}{44{,}5 \times S} + 0{,}015d + 1{,}0$$

For superheater tubes :

$$t = \frac{WP \times d}{K} + 1{,}5$$

where WP = working pressure in the boiler, in kg. per cm.$^2$,

d = external diameter, in millimetres,

S = minimum tensile strength of the tube material, in kg. per mm.$^2$,

t = thickness, in millimetres,

K is a coefficient given in Table 2.

The estimated metal temperature of the superheater tubes is to be stated when plans are submitted for approval but in no case is a temperature less than the maximum steam temperature plus 28° C. to be taken when evaluating K. For temperatures intermediate between those listed in the table and for carbon steels with tensile strengths intermediate between 32 and 44 kg. per mm.$^2$, the values of K may be obtained by interpolation.

## TABLE 2

| TUBE STEEL | Minimum tensile strength Kg. per mm.$^2$ | SUPERHEATER TUBES—VALUE OF COEFFICIENT K AT FOLLOWING METAL TEMPERATURES IN °C. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 343 | 371 | 399 | 427 | 454 | 482 | 510 | 538 | 566 | 593 | 621 | 649 |
| Carbon ... ... | 31,5 | 1410 | 1350 | 1270 | 1130 | 960 | 770 | — | — | — | — | — | — |
| | 44 | 1970 | 1830 | 1690 | 1410 | 1130 | 770 | — | — | — | — | — | — |
| ½% Mo. ... ... | 39,5 | 1760 | 1760 | 1760 | 1760 | 1760 | 1550 | 1130 | — | — | — | — | — |
| 1% Cr. ½% Mo. ... | 42,5 | 1900 | 1900 | 1900 | 1900 | 1900 | 1620 | 1410 | 980 | 630 | — | — | — |
| 2¼% Cr. 1% Mo. ... | 42,5 | 1900 | 1900 | 1900 | 1900 | 1900 | 1760 | 1550 | 1270 | 980 | — | — | — |
| 18% Cr., 12% Ni., 1% Nb. ... ... | 55 | 1970 | 1950 | 1940 | 1930 | 1910 | 1900 | 1880 | 1860 | 1830 | 1410 | 980 | 700 |

NOTE: For 18 % Cr., 12 % Ni., 1 % Nb. material, the Niobium content is not to be less than 10 times the Carbon content.

The thicknesses derived from these formulæ are minima and further provision is to be made for minus tolerances where necessary.

Where it is proposed to use other alloy steels for superheater tubes, particulars are to be submitted for special consideration in accordance with J 1402.

The formula for boiler tubes does not provide for adverse corrosion conditions and boiler tubes intended for low pressure boilers of 17,5 kg. per cm.$^2$ working pressure and under with open feed systems are to be made 0,5 mm. thicker than required by the formula.

**1616** The thickness of downcomer tubes and pipes which form an integral part of the boiler and which are not exposed to combustion gases is to comply with the Rules for steam pipes.

### Standpipes

**1617** Where standpipes and branches are attached to drums or headers by means of welding or by screwing and seal welding the minimum wall thickness for metal temperatures up to 343° C. is to be determined by the following formula but in no case is to be less than 6 mm.:—

$$t = \frac{D}{23} + 4{,}8$$

where t = thickness of standpipe or branch, in millimetres,

D = nominal bore, in millimetres.

For metal temperatures above 343° C., the wall thickness is to be not less than that required by the above formula or by the formula for shells in 1602, whichever is the greater.

**1618** Every flange is to have a fillet with a radius not less than the thickness of the neck to which it is attached.

## Section 17

## BOILER MOUNTINGS AND FITTINGS FOR WATER TUBE BOILERS

### Safety Valves

**1701** Water tube boilers are to be fitted with not less than two safety valves of area and design in general accordance with the requirements of J 405 to J 409, except that the minimum diameter of high discharge type valves may be 25 mm. or equivalent free area.

Each saturated steam drum and each superheater are to be provided with at least one safety valve.

Where the superheater forms an integral part of the boiler the relieving capacity of the superheater safety valve(s), based on the reduced pressure at the superheater outlet, may be included as part of the total relieving capacity required for the boiler. As some National Authorities limit the proportion of the superheater safety valve relieving capacity which may be credited towards the total capacity required for the boiler, Builders should give attention to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered.

The boiler and superheater safety valves are to be so disposed and proportioned between saturated steam drum and superheater outlet that the superheater will be protected from overheating under all service conditions, including an emergency stop of the ship at full power.

Where it is proposed to fit full bore safety valves operated by independent pilot valves, the arrangements are to be submitted for consideration. The pipes connecting pilot valves and main valves are to be of ample bore and wall thickness to minimise the possibility of obstruction and damage.

Where it is impracticable to attach safety valves directly to the superheater the valves are to be located as near as possible thereto and fitted to a branch piece connected to the superheater outlet pipe.

In high temperature installations the drains from safety valves are to be led to a tank or other place where high temperature steam can be safely discharged.

### Waste Steam Pipe

**1702** The waste steam pipe and passages leading to it from the safety valves are to be in general accordance with the requirements of J 411.

In installations operating with a high degree of superheat, consideration is to be given to the high temperatures which waste steam pipes, silencers and surrounding spaces will attain when the superheater safety valves are blowing during accumulation tests and in service; adequate protection against heat effects is to be provided to the Surveyors satisfaction. Waste steam pipes are to be led well clear of electric cables and any parts or structures sensitive to heat or likely to distort; the pipes are to be insulated where necessary. In these installations each boiler should have a separate waste steam pipe system to atmosphere with supporting and expansion arrangements such that no direct loading is imposed on the safety valve chests.

### Safety Valve Settings

**1703** All boiler and superheater safety valves are to be set under steam to their respective working pressures which are to be not greater than 3 per cent above the pressure for which the boiler is approved. In the setting of superheater safety valves, allowance is to be made for the pressure drop through the superheater so that under discharge conditions the pressure in the boiler will not exceed the approved boiler pressure.

In no case shall the superheater safety valve setting exceed by more than 3 per cent the pressure for which the steam piping and shafting are approved.

### Accumulation Tests

**1704** Tests for accumulation of pressure are to be carried out with the stop valve closed and under full firing conditions for a period not exceeding 7 minutes. The accumulation is not to exceed 10 per cent of the working pressure.

Where accumulation tests might endanger the superheaters, consideration will be given in cases of oil-fired boilers to the omission of these tests, provided that application is made when the boiler plan and sizes of safety valves are submitted for approval, and that the safety valves are of an approved type for which the capacity has been established by test in the presence of the Surveyors or an approved independent authority, or for which the Society is satisfied, by long experience of accumulation tests, that the capacity is adequate.

When it is agreed to waive accumulation tests it will be required that the valve makers provide a certificate for each safety valve, stating its rated capacity at the approved working conditions of the boilers and that the boiler makers provide a certificate for each boiler stating its maximum evaporation.

The safety valves are to be found satisfactory in operation under working conditions during the trials of the machinery on board ship.

### Stop Valves

**1705** Where two or more boilers are connected together, stop valves of self-closing or non-return types are to be fitted.

### Water Level Indicators

**1706** Every boiler is to be fitted with at least two independent means of indicating the water level in it, one of which is to be a glass water gauge.

The other means is to be either an additional glass water gauge or an approved equivalent device other than test cocks, but where a steam and water drum exceeding 3,96 metres in length is fitted athwartships, two glass water gauges are to be fitted in suitable positions, one near each end of the drum.

**1707** The position of the glass water gauges of boilers in which the tubes are entirely drowned when cold is to be such that water is just showing in the glass when the water level in the steam drum is just above the top of the uppermost tubes when the boiler is cold. In boilers, the tubes of which are not entirely drowned when cold, the glass water gauges are to be placed, to the Surveyor's satisfaction, in the positions which have been found by experience to indicate satisfactorily that the water content is sufficient for safety when the boiler is worked under all service conditions.

### Feed Check Valves and Water Level Regulators

**1708** Two feed check valves, connected to separate feed lines, are to be provided for each boiler and are to be attached, wherever practicable, direct to the boiler or to an economiser which forms an integral part of the boiler.

Where, however, the arrangements necessitate the use of a common inlet pipe on the economiser for both main and auxiliary feed systems, this pipe is to be as short as practicable and the arrangement of check valves is to be such that either feed line can be effectively isolated without interruption of the feed water supply to the boiler.

At least one of the feed water systems is to be fitted with an approved feed water regulator whereby the water level in the boilers is controlled automatically. (*See* E 7 for arrangements and details of boiler feed systems.)

**1709** The feed check valves are to be fitted with efficient gearing, whereby they can be satisfactorily worked from the stokehold floor, or other convenient position.

**1710** Standpipes on boilers, for feed inlets, are to be designed with an internal pipe to prevent direct contact between the feed pipe and the boiler shell or end plates with the object of minimizing thermal stresses in these plates.

Similar arrangements are to be provided for desuperheater and other connections where significant temperature differences occur in service.

### Mountings and Fittings

**1711** Mountings and fittings not mentioned in this Section are to be in accordance with the requirements of J 4.

## WELDED PRESSURE VESSELS

*For list of manufacturers of Class 1 Welded Pressure Vessels see appendix to this Chapter.*

### Section 18

#### General

**1801** The requirements of Sections 18 to 24, except where otherwise stated, are applicable to boilers, air receivers, heat exchangers and other pressure vessels of fusion welded construction intended for marine services, but excluding vessels containing radioactive materials or gases.

**1802** The term "fusion weld" is, for the purpose of these requirements, applicable to welded joints made by the metal arc process with covered electrodes or other electric arc process in which the arc stream and the deposited metal are shielded from atmospheric contamination. The welding may be done by hand or by machine.

#### Materials

**1803** Materials used in the construction of welded pressure vessels are to be of weldable quality steel and are to be manufactured and tested in accordance with the relevant requirements of Chapter P.

The tensile strengths of mild steel pipes, forgings and castings are not to exceed 55 kg. per mm.$^2$ The tensile strengths of carbon and carbon-manganese steel plates are to be within the range of 38 to 60 kg. per mm.$^2$ subject to the limitation of application of P 307.

**1804** Where it is proposed to use alloy or other steels not covered in Chapter P, specifications detailing the mechanical properties, chemical composition and heat treatment are to be submitted for special consideration. As the strengths of such steels are sensitive to heat treatment, check tensile tests after hot forming, normalising, and stress relieving at the fabrication works will, in general, be required.

**1805** All steels for Class 1 vessels are to be killed (*see* P 307); steels for Classes 2 and 3 vessels may be killed or semi-killed. All these steels are to contain not more than 0,05 per cent sulphur and 0,05 per cent phosphorus.

#### Plans

**1806** Plans in triplicate, showing full constructional features of the vessel and dimensional details of the weld grooves for longitudinal and circumferential seams and attachments, together with particulars of the electrodes and of the mechanical properties of the materials are to be submitted before construction is commenced.

#### Electrodes

**1807** Where a pressure vessel is to be made of alloy steel and where the scantlings have been approved on the basis of the high temperature properties of the material, particulars of the electrodes to be used including typical mechanical properties and chemical composition of the deposited weld metal are to be submitted for approval.

Particulars of typical creep, rupture and ductility properties of the deposited weld metal at elevated temperatures are also to be submitted when required.

#### Classification of Fusion Welded Pressure Vessels

**1808** For Rule purposes pressure vessels are graded as follows:—

CLASS 1

Pressure parts of boilers and fired pressure vessels intended for working pressures above 3,5 kg. per cm.$^2$ Pressure parts of steam heated steam generators where the working pressure exceeds 11,5 kg. per cm.$^2$, or where the working pressure in kg. per cm.$^2$ multiplied by the internal diameter of the shell in mm. exceeds 14700.

Other pressure vessels where the shell thickness exceeds 38 mm.

CLASS 2

Pressure parts of boilers and fired pressure vessels not included in Class 1.

Pressure parts of steam heated steam generators not included in Class 1.

Other pressure vessels where the working pressure exceeds 17,5 kg. per cm.$^2$, or the metal temperature exceeds 149° C., or where the working pressure in kg. per cm.$^2$ multiplied by the actual thickness of the shell in mm. exceeds 160.

Maximum shell thickness 38 mm.

CLASS 3

Vessels not included in Classes 1 and 2.

Maximum shell thickness 16 mm.

**1809** In special circumstances relating to service conditions, materials, operating temperature, the carriage of dangerous gases and liquids, etc., it may be necessary to include other pressure vessels in the Class 1 category.

**1810** All Class 1 vessels are required to be heat treated. Certain Class 2 vessels, as described in the following paragraph, are required to be heat treated and are graded as Class 2A. Other Class 2 vessels, graded as Class 2B, and all Class 3 vessels are not required to be heat treated.

Pressure parts of boilers, fired pressure vessels and steam heated steam generators in Class 2 category are required to be heat treated. Other vessels in Class 2 are required to be heat treated where the shell thickness in mm. exceeds $\frac{D}{130} + 10$ or 32 mm. whichever is the smaller where D=internal diameter of vessel in mm.

For heat treatment of pressure vessels *see* J 1925 to J 1929.

**1811** Vessels which are required to comply with Classes 2 or 3 standards will, if manufactured in accordance with the requirements for a superior class, be approved with the scantlings appropriate to that class.

**1812** The conditions of manufacture and test for the three classes are given in the following Table 3.

**TABLE 3**

| Class | Radiographic examination | Heat Treatment | Routine Weld Tests | Hydraulic Tests |
|---|---|---|---|---|
| 1 | required | required | required | required |
| 2A | — | required | required | required |
| 2B | — | — | required | required |
| 3 | — | — | — | required |

### Scantlings of Welded Pressure Vessels

**1813** For the scantlings of shell and ends of cylindrical boilers, water tube boilers and steam heated steam generators *see* J 16 and for air receiver ends *see also* J 24.

For the scantlings of shells and ends of other welded pressure vessels, *see* 1815 and 1816.

### Joints

**1814** Longitudinal joints for all classes of vessels are to be butt joints. Circumferential joints for Class 1 vessels are to be butt joints and for Classes 2 and 3 vessels may be either butt joints or lap joints.

### Shells of Cylindrical and Spherical Vessels

**1815** The thickness of shell plates is to be determined by the following formula but in no case is to be less than 5 mm.

$$WP = \frac{C \times f \times (T - 1{,}6)}{d} \qquad T = \frac{WP \times d}{C \times f} + 1{,}6$$

where WP = maximum working pressure in kg. per cm.$^2$,
T = thickness of shell plate in millimetres,
f = nominal stress in kg. per cm.$^2$,
d = internal diameter of the shell in millimetres,
C = coefficient from the following table.

| Vessel Grade | Coefficient C | |
|---|---|---|
| | Cylindrical Vessels | Spherical Vessels |
| Seamless | 2 | — |
| Welded Class 1 | 1,9 | 3,8 |
| Welded Class 2A | 1,6 | 3,2 |
| Welded Class 2B | 1,5 | 3,0 |
| Welded Class 3 | 1,05 | — |

For pressure vessels with working metal temperatures of 316° C. and under f is to be taken as 1/3,5 of the specified minimum tensile strength of the material and for those operating at metal temperatures above 316° C. the nominal stresses at temperatures given in Table 1, J 1602, are to be used. For pressure vessels intended for the carriage of liquefied petroleum gases *see also* J 25.

### Dished End Plates

**1816** Ends dished to partial spherical form and subject to pressure on the concave side, are to comply with the following requirements:—

(a) The inside radius of dishing R is not to be greater than the outside diameter D of the end.

(b) The inside corner radius r is not to be less than four times the thickness of the end or 10 per cent of the inside diameter whichever is greater.

(c) The permissible working pressure is to be determined by the following formula:—

$$WP = \frac{8{,}4\,(T - 0{,}8) \times f \times h \times J}{D^2} \times \left\{ \frac{\frac{r}{R} + 0{,}05}{\frac{r}{R} + 0{,}15} \right\}$$

where WP = maximum working pressure in kg. per cm$^2$.,
T = thickness of end in millimetres after dishing. Where ends are made from one plate the thickness is to be not less than that of a seamless shell of the same diameter and material,

f = nominal stress in kg. per cm.$^2$ having values as stated in 1815,

J = 1,00 for ends made from one plate
0,95 for ends made from two or more plates with Class 1 welded seams
0,80 for ends made from two or more plates with Class 2A welded seams
0,75 for ends made from two or more plates with Class 2B welded seams,

D = outside diameter of end in millimetres,

R = inside radius of dishing in millimetres,

r = inside radius of corner in millimetres,

h = external height of dishing, in millimetres, measured from centre of corner radius which is to be calculated as follows:—

$$h = R_o - \sqrt{\left(R_o - \frac{D}{2}\right)\left(R_o + \frac{D}{2} - 2r_o\right)}$$

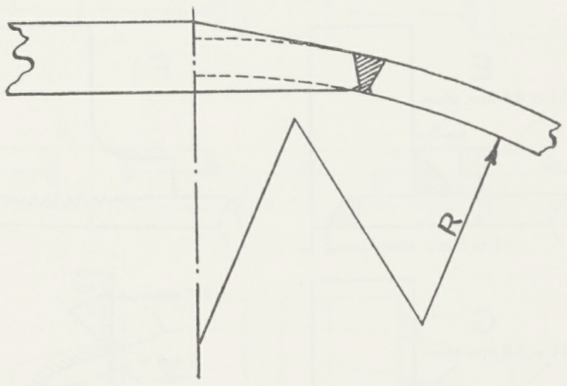
$R_o$ = outside radius or dishing in millimetres,

$r_o$ = outside corner radius in millimetres.

### Hemispherical End Plates

**1817** The thickness of hemispherical ends made from one or more plates is to be determined by the formula in 1815 with the value of coefficient C corresponding to the appropriate class of welded pressure vessel.

Where hemispherical ends are butt welded to cylindrical shells the thickness of the shell is to be reduced by taper to that of the end and the centre of the hemisphere is to be so located that the entire tapered portion of the shell and the butt weld are within the hemisphere (*see* sketch).



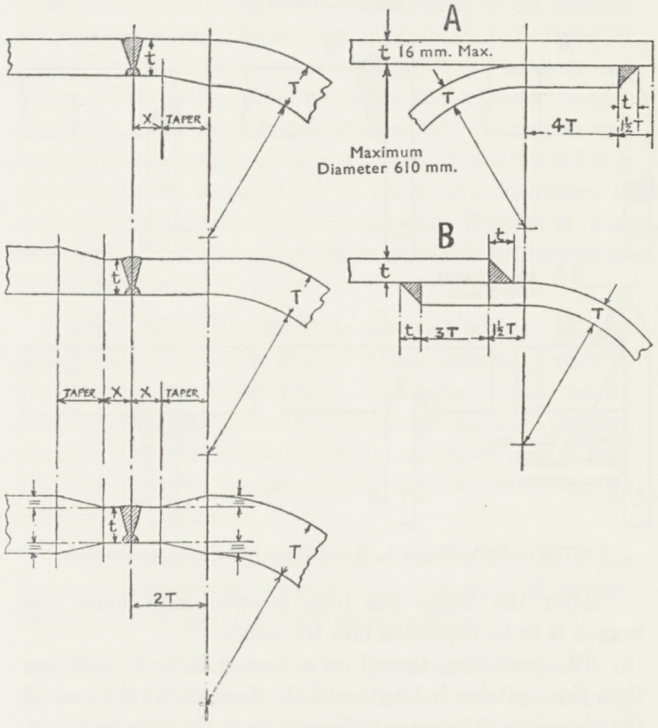

If the hemispherical end is provided with a parallel portion the thickness of this portion is to be not less than that of a seamless or welded shell, whichever is applicable, of the same diameter and material.

**1818** The scantlings of dished ends for Class 3 pressure vessels subject to pressure on the convex side are to be determined by the formula in J 2404.

**1819** For typical acceptable methods of attaching dished ends to cylindrical shells and for limitations of different types *see* Fig. 1. Types A and B are to be made a tight fit in the cylindrical shell. (*See* J 2206.)

Parallel portions marked x of about 32 mm. are to be provided for Class 1 pressure vessels to facilitate the radiographic examination of the welds. The thickness t of the parallel portions is to be not less than that of an unpierced cylindrical shell of seamless or welded construction, whichever is applicable. The taper on each side of the plates is to be not greater than 1 in 4.

FIG. 1 TYPICAL ACCEPTABLE METHODS OF ATTACHING DISHED END PLATES TO CYLINDRICAL SHELLS




| Type | Acceptable for |
|---|---|
| A | Class 3 pressure vessels |
| B | Class 2 and 3 pressure vessels |
| Others | Class 1, 2 and 3 pressure vessels |

### Flat End Plates

**1820** The scantlings of flat end plates for Classes 1, 2 and 3 pressure vessels are to be determined by the formula in J 1607.

**1821** For typical acceptable methods of attaching flat ends to small cylindrical shells and for application of different types *see* Fig. 2.

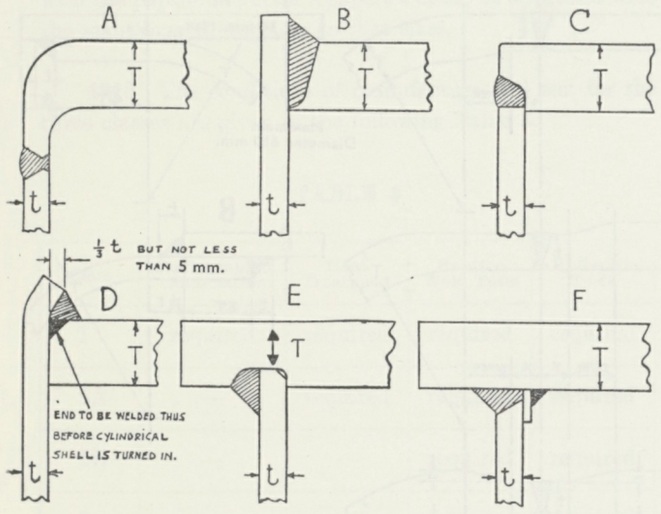
### Standpipes

**1822** The scantlings of standpipes are to be determined by the requirements of J 1617.

For acceptable methods of attaching flanges to standpipes and service limitations of the various types *see* Fig. 3.

Where flanges are secured by screwing, the branch and flange are to be screwed with a vanishing thread, and the diameter of the screwed portion of the branch over the thread is to be not less than the outside diameter of the unscrewed branch.

FIG. 2 TYPICAL ACCEPTABLE METHODS OF ATTACHING UNSTAYED FLAT END PLATES TO SMALL PRESSURE VESSELS, CIRCULAR AND SQUARE HEADERS AND HEAT EXCHANGERS




NOTE:—Ends, Types A, B and C are to be used for Headers.

After the flange has been screwed hard home the branch is to be expanded into the flange.

The vanishing thread on a branch is to be not less than three pitches in length and the diameter at the root of the thread is to increase uniformly from the standard root diameter to the diameter at the top of the thread. This may be produced by suitably grinding the dies, and the flange should be tapered out to the same formation.

### Attachment of Standpipes, Branches, Compensating Plates and Pads

**1823** Compensating plates and pads are to be bedded closely to the surface to which they are to be welded, and compensating plates are to be provided with a tell-tale hole not greater than 9,5 mm. in diameter open to the atmosphere.

For acceptable methods of attaching standpipes, branches, compensating plates and pads *see* Fig. 4.

Alternative methods of attachment may be accepted provided details are submitted for consideration.

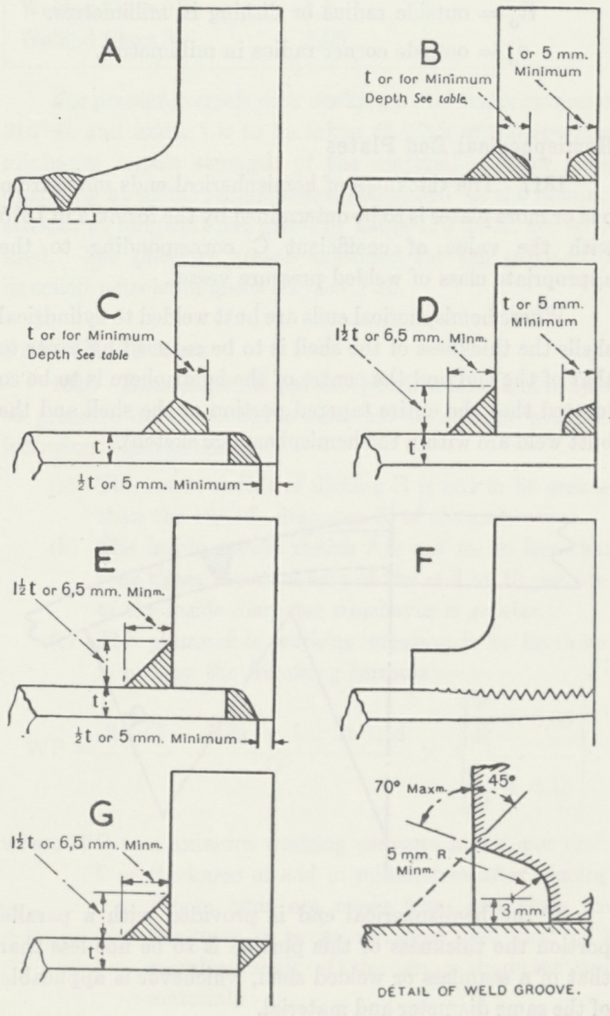
### Access Arrangements

**1824** Manhole, inspection and cleaning openings and doors for cylindrical boilers, watertube boilers and air receivers are to be in accordance with the relevant sections of this chapter.

### Cross-reference

**1825** For compensation for openings in shell and end plates, *see* J 1608 to J 1612.

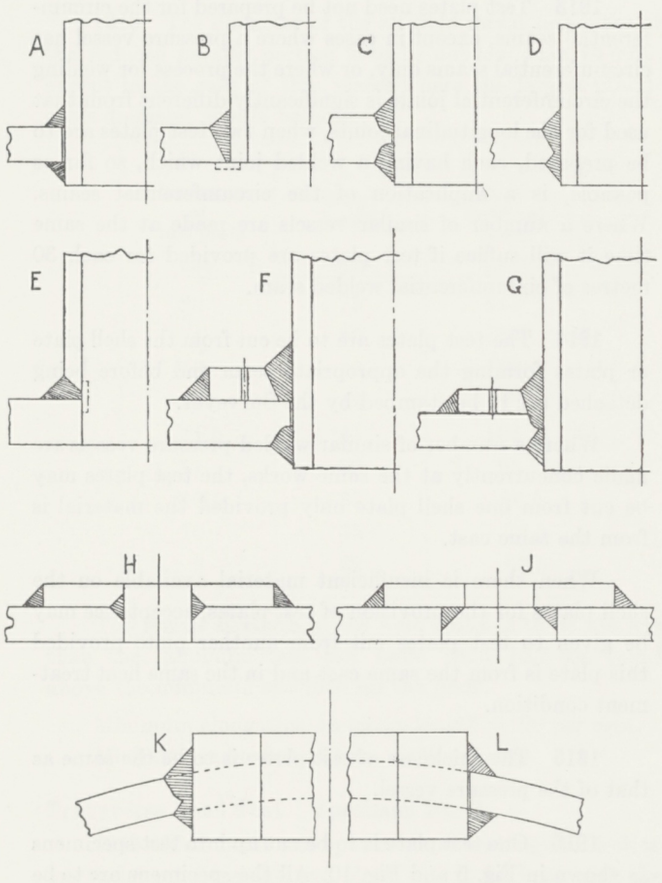
FIG. 3 ACCEPTABLE METHODS OF ATTACHING FLANGES TO STEEL BRANCHES OR STANDPIPES



| Pipe Bore | Minimum Depth of Groove for flanges B and C |
|---|---|
| 13mm. and 19mm. | 6,5mm. |
| 25mm. to 38mm. | 8mm. |
| 50mm. and over | 9,5mm. |

| Type of Flange Attachment | Service and Rating | | | |
|---|---|---|---|---|
| | Feed, Air, Oil Fuel and other fluids | | Steam | |
| | Pressure kg. per cm.² | Temperature °C. | Pressure kg. per cm.² | Temperature °C. |
| A | All Conditions | | All Conditions | |
| B & C | All Conditions | | 52,5 | 454 |
| D & E | 52,5 | 260 | 38,5 | 399 |
| F | 42 | | 31,5 | |
| G | 17,5 | | 17,5 | 260 |

FIG. 4 TYPICAL ACCEPTABLE METHODS OF ATTACHING BRANCHES AND PADS




NOTE:—Types A and L attachments are not to be used for openings which require to be compensated. Backing Rings may be used with Types B and E.

## Section 19

## REQUIREMENTS FOR CLASS 1 FUSION WELDING

### Preliminary Conditions and Tests

**1901** Fusion welded pressure vessels constructed to Class 1 requirements will be accepted only if manufactured by firms equipped and competent to undertake high quality welding. In order that firms may be approved for this purpose, it will be necessary for the Surveyors to visit the firm's works for the purpose of inspecting the welding plant, equipment and procedure and to arrange for the carrying out of preliminary tests and the survey during construction and testing of a full size welded pressure vessel as stated in 1904, 1905 and 1906.

**1902** The welding plant and equipment are to be suitable for undertaking work of the standard required for Class 1 welding and are to be maintained in an efficient working condition. The welding apparatus is to be installed under cover and so arranged that the welding work is carried out in positions free from draughts and adverse weather conditions. The procedure should include the regular and systematic supervision of the welding work, and the welding operators are to be subjected by the work's supervisors to periodic tests for quality of workmanship. Records of these tests are to be kept and are to be available for inspection by the Surveyors.

**1903** The works should be equipped with an efficient testing laboratory which should include apparatus suitable for carrying out tensile, bend and impact tests, micro-examination of specimens and X-ray examination of pressure vessels. The works should also be equipped with a suitable heat treating furnace having satisfactory means for temperature control.

Alternative arrangements which, in the opinion of the Surveyors, ensure an equally high standard of quality control may be submitted for consideration.

**1904** Preliminary tests to demonstrate the quality of the welding work are to be carried out by the firm on specimens cut from test plates welded under the supervision of the Surveyors. The test plates are to comply with 1907, but are to be at least 19 mm. thick. The welded seams of the test plates are to be radiographed. The Surveyors are to select portions of the test plates containing the welded joint from which specimens are to be provided for the following:—

(1) Tensile, bend, impact, hardness and fatigue tests.

(2) Micrographs at 100 and 300 magnifications, of weld centre, fusion zone and parent plate.

(3) Macrograph of full section of weld.

(4) Chemical analysis of deposited weld metal.

(5) Chemical analysis of test plates.

As an alternative to (5), a guaranteed analysis obtained from the steel makers will be accepted.

**1905** Where the welding is carried out by an established and approved process, the fatigue tests and micrographs listed in 1904 will in general not be required.

**1906** A full size pressure vessel is to be constructed in accordance with the requirements of these Rules for Class 1 fusion welded pressure vessels under the supervision of the Surveyors.

**1907** The approval of works for the manufacture of Class 1 welded pressure vessels will be limited to the grade of vessel which has been the subject of test in obtaining approval. Grading will be governed by shell thickness at the welded joint and by the quality of the steel. For grading purposes steels will be grouped in three categories, namely, (1) carbon and carbon-manganese steels (38–54 kg. per mm.$^2$), Grades 1, 2, 3 and 4, (2) carbon and carbon-manganese steels (50–60 kg. per mm.$^2$) Grade 5, and (3) low alloy steels. For the foregoing reasons, therefore, the test plates and full size pressure vessel mentioned in paragraphs 1904, 1905 and 1906 are to be representative, as regards materials and approximate shell thickness, of the production vessels for which approval is desired.

**1908** On completion of the inspection and tests, the Surveyor's report including the results of the preliminary tests and the tests of the full size pressure vessel is to be submitted for the consideration of the Committee. The report should also include the radiographs and particulars of any fusion welded pressure vessels previously constructed by the firm.

**1909** If a firm intends to manufacture pressure vessels either of a different grade, or by means of a different welding process than used in the construction of the full size vessel on which the original approval of the works was based, a series of procedure tests may be required to cover the new conditions of manufacture. In the first instance, however, particulars and plans showing full details of the proposed vessel or new welding process are to be submitted, when the necessity for procedure tests will receive consideration.

**1910** Where firms desire their name to be included in the Society's list of firms recognised by the Committee as experienced manufacturers of Class 1 fusion welded pressure vessels, they should make application at the initial stages of having their works approved.

### Routine Tests for Class 1 Fusion Welded Pressure Vessels

**1911** Two test plates should be prepared for each pressure vessel. They should be attached to the shell plate in such a manner that the edges to be welded are a continuation and duplication of the corresponding edges of a longitudinal joint. The welding process, procedure and technique are to be the same as employed in the welding of the longitudinal joint. Test plates are to be so supported, during welding, that warping is reduced to a minimum.

**1912** The test plates are to be straightened before being subjected to the same heat treatment as given to the pressure vessel.

**1913** Test plates need not be prepared for the circumferential seams, except in cases where a pressure vessel has circumferential seams only, or where the process for welding the circumferential joints is significantly different from that used for the longitudinal joints, when two test plates are to be prepared, each having a welded joint which, so far as possible, is a duplication of the circumferential seams. Where a number of similar vessels are made at the same time it will suffice if test plates are provided for each 30 metres of circumferential welded seam.

**1914** The test plates are to be cut from the shell plate or plates forming the appropriate seam and before being detached are to be stamped by the Surveyor.

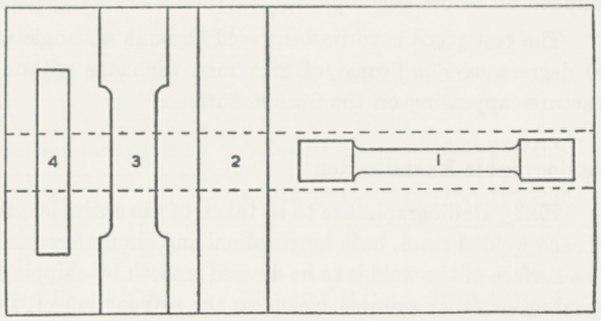
Where a number of similar welded pressure vessels are made concurrently at the same works, the test plates may be cut from one shell plate only provided the material is from the same cast.

When there is insufficient material available on the shell plates for the provision of test plates, acceptance may be given to test plates cut from another plate provided this plate is from the same cast and in the same heat treatment condition.

**1915** The thickness of test plates is to be the same as that of the pressure vessel.

**1916** One test plate is to be cut up into test specimens as shown in Fig. 5 and Fig. 10. All the specimens are to be cut from a plate of suitable length and are to comply with the test requirements detailed in 1918 to 1922.

FIG. 5




(1) Tensile, all weld metal. (3) Tensile (joint).

(2) Bend. (4) Macro.

**Retests**

**1917** If any of the tests fail, two retests are to be made on specimens cut from the second test plate. All retests are to comply fully with the test requirements.

**Tensile Test for all Weld Metal. Specimen No. 1**

**1918** The diameter of the all weld metal test piece at the reduced parallel portion is to be not less than 14 mm., except in the case of thin plates where the largest practicable diameter should be used.

| Diameter of test piece mm. | Gauge length mm. | Cross Sectional Area mm.² |
|---|---|---|
| 20 | 75 | 314 |
| 14 | 50 | 154 |
| 13 | 46 | 133 |
| 12 | 43 | 113 |
| 11,5 | 41 | 104 |
| 11 | 39 | 95 |
| 10,5 | 37 | 86,5 |
| 10 | 35 | 78,5 |
| 9 | 32 | 63,5 |

The tensile strength of the weld metal is to be not less than the minimum and not more than 15,7 kg. mm.² above the minimum specified for the plate.

Minimum elongation on gauge length = 20 per cent.

Minimum reduction of area = 35 per cent.

**Transverse Bend Test. Specimen No. 2**

**1919** Two bend test specimens of rectangular section are to be cut from the test plate, one to be bent with the outer surface of the weld in tension, and the other with the inner surface in tension.

The specimens are to be cut transversely to the weld and are to have a width equal to 1,5 times the thickness, and the mid portion of the specimens is to coincide with the centre line of the weld. The edges may be rounded off to a radius not exceeding 10 per cent of the thickness of the specimen.

In plate thicknesses not exceeding 32 mm., the thickness of the specimens should be equal to the thickness of the test plate. Where the plate thickness exceeds 32 mm., the specimens should, in all cases, have a thickness of 32 mm., and width of 48 mm. These should be prepared by discarding metal from the surfaces of the specimens which will be in compression when the test is applied. *See* Figs. 6 and 7.

Where the thickness of the plate permits, the bend specimens may be prepared as shown in Fig. 8.

For each specimen the weld reinforcement should be removed by buffing or machining so that the outer and inner surfaces of the weld are flush with the surface of the plate.

Each specimen is to be bent cold without fracture through an angle of 180 degrees, over a former having diameter not greater than three times the thickness of the specimen. The distance between supports should be not more than 5,2 times the thickness of the specimen.

FIG. 6 NORMAL BEND SPECIMEN

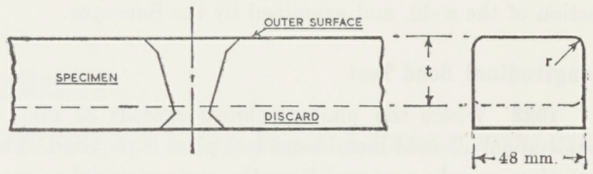



FIG. 7 REVERSE BEND SPECIMEN

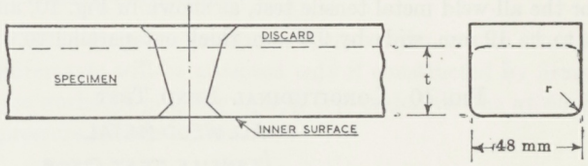
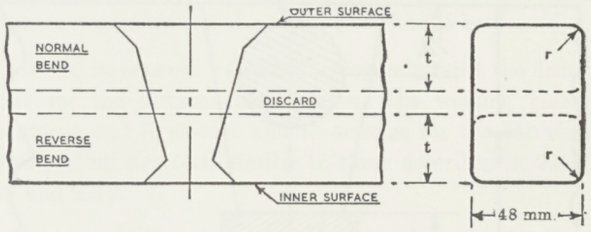



FIG. 8 NORMAL AND REVERSE BEND SPECIMENS CUT FROM SINGLE PIECE OF PLATE



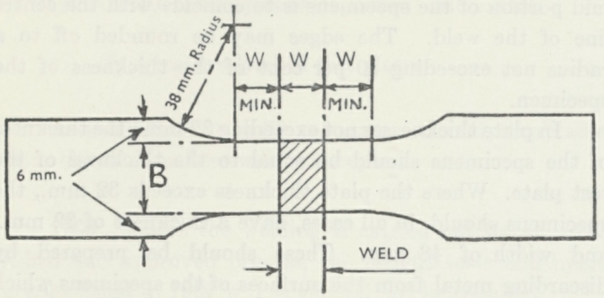

t = thickness of the specimen which is the thickness of the plate or 32 mm., whichever is the lesser.

r = corner radii not exceeding 0,1t.

NOTE:—Where t is less than 32 mm. the width of the specimen is to be 1,5t.

**Tensile Test for Joint. Specimen No. 3**

**1920** FIG. 9




B = Not less than thickness of plate with a minimum width of 38 mm.

An equivalent form of test piece to that shown in Fig. 9 may be accepted.

The weld is to be machined flush with plates on both sides.

The ultimate tensile strength is to be not less than the minimum specified for the plate. If the test piece breaks in the plate or fusion zone at not less than 95% of the minimum specified for the plate the test may be accepted.

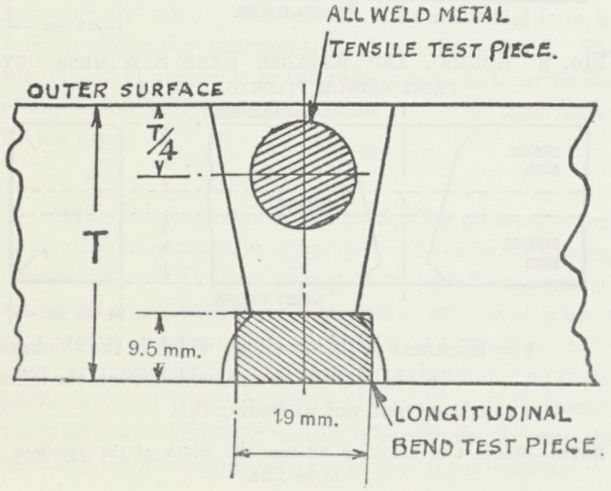
**Macro Specimen. Specimen No. 4**

**1921** The specimen is to be etched across the full section of the weld, and examined by the Surveyor.

**Longitudinal Bend Test**

**1922** Where the plate thickness exceeds 38 mm. a longitudinal all-weld metal bend test piece is required. The test piece may be prepared from the same material as used for the all-weld metal tensile test, as shown in Fig. 10, and is to be 19 mm. wide by 9,5 mm. thick cut parallel to the seam. The sharp edges of the test piece may be slightly rounded off before bending.

FIG. 10 LONGITUDINAL BEND TEST




The test piece is to be bent cold through an angle of 90 degrees over a former of 28,5 mm. diameter without fractures appearing on the tension surface.

**Radiographic Examination**

**1923** Radiographs are to be taken of the entire length of each welded seam, both longitudinal and circumferential. The surface of the weld is to be dressed smooth by chipping, grinding or other suitable means to the satisfaction of the Surveyor. The radiographs are to be marked in such a way that the corresponding portions of the welded seams can be readily and accurately identified. The radiographs are to be examined by the Surveyor who will indicate whether any repairs are necessary. On completion of repairs the affected portions of the seams are to be re-radiographed.

Penetrameters of approved type are to be placed at each end of each radiograph. They are to be placed adjacent to the welded seam and on the surface facing the source of radiation. The X-ray technique employed is to be such that the thickness of the penetrameter corresponding to 2 per cent of the thickness of the parent plate will be clearly shown on the radiograph.

The use of gamma rays may be permitted in exceptional circumstances, when details should be submitted for consideration.

**Magnetic Crack Detection Examination**

**1924** Where vessels are made of carbon steel having a tensile strength exceeding 55 kg. per mm.$^2$, or of alloy steel, all welds attaching standpipes, compensating plates, etc., to the vessel, which cannot be radiographed, are to be examined by magnetic crack detection, or other approved non-destructive methods.

**Heat Treatment**

**1925** Each pressure vessel is to be efficiently heat treated on completion of the welding of all joints and attachments to shell and ends, and before the hydraulic test is carried out.

Heat treatment is to be carried out in a properly constructed and temperature controlled furnace and is to consist of heating the vessel slowly and uniformly to a suitable stress relieving temperature, soaking for a suitable period, followed by uniform cooling to atmospheric temperature. The temperature and soaking periods are to be selected which will relieve residual stress without undue reduction of material tensile strength.

Recommended temperatures for stress relief are given in the following table:—

| Type of Steel | Soaking Temperature | |
|---|---|---|
| Carbon<br>Carbon-manganese | 580–620° C. | 1080–1150° F. |
| ½% Mo. | 620–660° C. | 1150–1220° F. |
| 1% Cr. ½% Mo. | 620–660° C. | 1150–1220° F. |
| 2¼% Cr. 1% Mo. | 650–690° C. | 1200–1270° F. |

Soaking periods for the materials listed in the above table are to be at least one hour per 25 mm. of plate thickness with a minimum period of one hour, except that for carbon and carbon manganese steels the period of soaking is to be increased by one hour, i.e. to one hour per 25 mm. of plate thickness plus one hour with a minimum period of two hours.

In cases where other materials are used for pressure vessel construction, full details of the proposed heat treatment are to be submitted for consideration.

**1926** Where pressure vessels are of such dimensions that the whole length cannot be accommodated in the furnace at one time, the pressure vessels may be heated in sections provided sufficient overlap is allowed to ensure the heat treatment of the entire length of the longitudinal seam.

**1927** Test plates should be heat treated in the same furnace and at the same time as the pressure vessels which they represent. In special cases, however, it may be permissible to heat treat the test plates separately from the pressure vessels provided the Surveyor is satisfied with the means adopted to ensure that the following factors will be the same for the pressure vessels as for their respective test plates:—

Rate of heating.

Maximum temperature.

Time held at maximum temperature.

Conditions of cooling.

**1928** Where a number of test plates are heated together in a furnace, care is to be taken to ensure that each plate is uniformly exposed to the heat of the furnace.

**1929** Where it is proposed to adopt special methods of heat treatment full particulars are to be submitted for consideration. In such cases it may be necessary to carry out tests to show the effect of the proposed heat treatment.

### Hydraulic Test

**1930** The hydraulic test pressure is to be 1,5 times the working pressure. (For steam and water drums of water tube boilers, *see* J 1509).

Where a vessel is designed for use at elevated temperatures a test pressure (TP) is to be applied, such that the vessel is subjected under hydraulic test to approximately the same wall stress as a vessel operating at a metal temperature below 343° C. as follows:—

$$TP = 1{,}5\ WP \times \frac{f \text{ at } 343^\circ \text{ C.}}{f \text{ at working temperature}}$$

where f is the nominal stress obtained from Table 1.

Whilst under this test the pressure vessel is to be well hammered on both sides of, and close to, the welded seams.

This hammer test is not required for vessels where the longitudinal and circumferential seams have been radiographed.

### Modification of Requirements

**1931** In the case of firms of large experience some modification may be permitted in regard to the requirements of 1904 to 1906.

## Section 20

## REQUIREMENTS FOR CLASS 2 FUSION WELDING

### Preliminary Conditions

**2001** Pressure vessels made in accordance with Class 2 requirements will be accepted only if constructed by firms whose works are properly equipped to undertake the welding of pressure vessels of this Class.

The welding plant is to be installed under cover and is to be maintained in an efficient working condition and adequate supervision of the welding work is to be provided.

It will be necessary for the Surveyors to visit the firm's works for the purpose of inspecting the welding plant, equipment and procedure and to arrange for the carrying out of preliminary tests similar to those described in 2010, 2011 and 2012.

On completion of the inspection and tests, the Surveyor's report including the results of the preliminary tests and particulars of the fusion welded pressure vessels previously constructed by the firm are to be submitted for the consideration of the Committee.

### Routine Tests for Class 2 Fusion Welded Pressure Vessels

**2002** Two test plates should be prepared for each pressure vessel. They should be attached to the shell plate in such a manner that the edges to be welded are a continuation and duplication of the corresponding edges of a longitudinal joint. The welding process, procedure and technique are to be the same as employed in the welding of the longitudinal joint. Test plates are to be so supported during welding that warping is reduced to a minimum.

**2003** In cases where a number of Class 2 pressure vessels are made concurrently at the same works, and the plate thicknesses do not vary by more than 5 mm., each 37 metres of welded seam, longitudinal plus circumferential, may be regarded as equivalent to one pressure vessel, the required number of test specimens being provided accordingly.

In these cases the thickness of the test plates is to be equal to that of the thickest shell plate used in the construction of the pressure vessels.

**2004** The test plates are to be straightened before being subjected to the same heat treatment as given to the pressure vessel.

**2005** Test plates need not be prepared for the circumferential seams, except in cases where a pressure vessel has circumferential seams only, or where the process for welding the circumferential joints is significantly different from that used for the longitudinal joints, when two test plates are to be prepared each having a welded joint which, so far as possible, is a duplication of the circumferential seams. Where a number of similar vessels are made at the same time, it will suffice if test plates are provided for each 30 metres of circumferential welded seam.

**2006** The test plates are to be cut from the shell plate or plates forming the appropriate seam and before being detached are to be stamped by the Surveyor.

Where a number of similar welded pressure vessels are made concurrently at the same works, the test plates may be cut from one shell plate only provided the material is from the same cast.

When there is insufficient material available on the shell plates for the provision of test plates, acceptance may be given to test plates cut from another plate provided this plate is from the same cast and in the same heat treatment condition.

**2007** The thickness of test plates is to be the same as that of the pressure vessel.

**2008** One test plate is to be cut up into test specimens as shown in Fig. 11. All the specimens are to comply with the test requirements detailed in 2010 to 2012.

FIG. 11

| | | |
|---|---|---|
| | | TENSILE |
| | WELD | BEND |
| | | BEND |
| | | NICKED BEND |

Specimens may be dressed in way of the weld and the sharp edges may be removed from the bend specimens.

### Retests

**2009** If any of the tests fail, two retests are to be made on specimens cut from the second test plate. All retests are to comply fully with the test requirements.

### Tensile Test

**2010** The shape of the specimen is to conform to the requirements of J 1920.

The ultimate tensile strength of the joint is to be not less than the minimum specified for the plate.

In case of Class 2A vessels if the test piece breaks in the plate or fusion zone at not less than 95% of the minimum specified for the plate the test may be accepted.

### Bend Tests

**2011** The width of the bend specimens is to be not less than 1,5 times the thickness, and the mid-portion of the specimens is to coincide with the centre line of the weld. One specimen is to be bent with the outer surface of the weld in tension, and the other specimen is to be bent with the outer surface of the weld in compression.

In both cases the specimens are to be bent without fracture through an angle of 180 degrees over a former, the diameter of which is not greater than three times the thickness of the specimen.

### Nicked Bend Tests

**2012** The specimen is to have a slot cut into each side of the weld. The specimen is then to be broken in the weld and the fracture is to reveal a sound homogeneous weld, substantially free from slag inclusions, porosity and coarse crystallinity.

### Heat Treatment

**2013** Where heat treatment is required to be carried out in respect of any pressure vessel, the requirements of J 1810 and J 1925 to J 1929 are to be complied with.

### Hydraulic Test

**2014** Hydraulic test to be carried out in accordance with the requirements of J 1930.

## Section 21

## REQUIREMENTS FOR CLASS 3 FUSION WELDING

### Preliminary Conditions

**2101** Pressure vessels of Class 3 grade will be accepted without routine weld tests if constructed by firms whose works are equipped to undertake the welding of pressure vessels of this type. The Surveyors are to be satisfied that the welding equipment, procedure and supervision of the work are adequate, and are to test the quality of the welds by preliminary tests and occasional tests at their discretion.

### Hydraulic Test

**2102** For pressure vessels intended for working pressures up to 7 kg. per cm.$^2$, the hydraulic test pressure is to be twice the working pressure. Where working pressures exceed 7 kg. per cm.$^2$ the hydraulic test pressure is to be 1,5 times the working pressure plus 3,5 kg. per cm.$^2$

Whilst under this test the pressure vessel is to be well hammered on both sides of, and close to, the welded seams.

## Section 22

## CONSTRUCTION AND INSPECTION OF FUSION WELDED PRESSURE VESSELS

*Note:—The following requirements are applicable to all classes of fusion welded pressure vessels.*

### Electrodes

**2201** Electrodes intended for use in the construction of pressure vessels are to be stored in a dry place. In order to ensure that the quality of the electrodes is being consistently maintained they are to be subjected to a regular system of periodic testing and inspection. Where routine tests are frequently carried out in respect of pressure vessels made in the normal course of production, such tests may be regarded as meeting the requirements of this paragraph.

### Welding Technique

**2202** Welding may be carried out by hand or by machine, and the current used in electric metallic arc welding may be direct or alternating. In welding branch pieces, pads and compensating rings, more than one run of weld metal is to be deposited. Longitudinal and circumferential seams may be reinforced by additional runs of weld metal.

### Preheating

**2203** Preheating is to be employed when necessitated by the joint restraint, thickness of the plate, and composition of the materials to be welded. Irrespective of plate thickness, welds in carbon steel, where the tensile strength is 55 kg. per mm.$^2$ or over, and welds in low alloy steels are to be preheated to a minimum temperature of 200° C. (392° F.). For carbon steels of lower tensile strength, preheating is to be used where the thickness exceeds 44,5 mm.

The method used for preheating is to be such as to ensure a uniformly heated band adjacent to the weld and to maintain the preheat temperature at all stages of welding until completion.

**2204** The outer surfaces of the welds may be flush with the surfaces of the plates joined, but no objection will be raised if the total thickness at the centre of the weld is greater than the thickness of the plates, provided the change of section is gradual and there is no undercutting at the sides of the weld.

**2205** Each run of weld metal is to be thoroughly cleaned and free from slag before the next run is deposited.

**2206** Butt joints are to be welded from both sides of the plate where practicable. Before welding is commenced from the second side the weld metal at the bottom of the first side weld is to be removed by chipping or other approved method. Butt joints welded from one side, with or without backing strips, are acceptable only where access for an internal weld is not practicable. In the latter circumstances, it is to be demonstrated that there is complete penetration and fusion at the root of the weld.

**2207** The welding of pressure vessels is to be carried out in the downhand horizontal position. In the case of circumferential seams means are to be adopted to ensure compliance with this requirement.

**2208** In cases where it is proposed to adopt fusion welding processes in which it may not be possible to comply fully with the foregoing requirements regarding technique, full particulars are to be submitted for consideration.

### Fabrication

**2209** Before welding, the assembly is to be examined. The shape and size of the joints are to be in accordance with the approved design. The butting edges of the plates form-

ing the longitudinal and circumferential seams are to be in line within a limit of 10 per cent of the plate thickness, but in no case exceeding 3 mm. for longitudinal joints and 5 mm. for circumferential joints.

**2210** The attachment of branches should be examined before and after welding.

**2211** During fabrication, the Surveyor is to be provided with opportunities for seeing the actual deposition of weld metal. The joints are to be examined at various stages during construction.

**2212** On completion of the welding, the seams are to be thoroughly examined before being dressed or machined. Parts showing evidence of blow-holes, slag inclusions, unsatisfactory penetration, porosity, or any other defect, are to be cut out and rewelded, and excessive undercutting made good.

**2213** Each pressure vessel is to be calibrated for distortion. The calibration is to be made after the heat treatment has been carried out. The drum or shell is to be circular at any section within a limit of one per cent of the designed internal diameter based on the difference between the maximum and minimum diameters of any section. Any departure from circularity is to be gradual and there is to be no local flat in way of the welded seam.

### Attachment of Fittings

**2214** The attachment by welding of any fitting, brackets, lugs, etc., to the main pressure shell after the final stress relieving treatment, is not permitted, except where the material involved is mild steel. In such cases welding will only be permitted provided it is necessitated by the method of construction being employed and prior approval of the Surveyor must be obtained before any welding is carried out. In no circumstances is any welding to be done after heat treatment on vessels made of carbon or carbon-manganese steel with tensile strength exceeding 54 kg. per mm.$^2$ or of alloy steel.

When fittings, lugs, etc., are attached by welding to the main pressure shell, the material of these attachments is to be of weldable quality and the welding is to be of a comparable standard to that required for the vessel.

## Section 23

## FORGE WELDED PRESSURE VESSELS

### General

**2301** The term forge weld is, for the purpose of these Rules, applicable to joints made between plates which are welded together by means of hammering or rolling and in which no added metal is included.

### Classification of Forge Welded Pressure Vessels

**2302 Class 1.** Pressure vessels made in accordance with the requirements of this class will be accepted only if they are constructed by firms whose names are included in the list of firms recognised by the Committee for the manufacture of Class 1 forge welded pressure vessels.

Approval of the following pressure vessels will only be given provided they be constructed and tested in accordance with the requirements of these Rules.

Pressure parts of boilers, and all fired pressure vessels intended for working pressures above 3,5 kg. per cm.$^2$

In special circumstances relating to pressure, temperature and service conditions, it may be considered necessary to include other pressure vessels in the Class 1 category.

**Class 2.** This class includes all forge welded pressure vessels not included in Class 1.

### Cylindrical Shells

**2303** For pressure vessels operating at metal temperatures of 343° C. and under, the thickness of cylindrical shells is to be determined by the following formula, but no plate is to be less than 6,5 mm. thick.

$$WP = \frac{K \times S}{D}(T-1,6), \qquad T = \frac{WP \times D}{K \times S} + 1,6$$

where WP = working pressure in kg. per cm.$^2$,

T = thickness of shell in mm.,

S = minimum tensile strength in kg. per mm.$^2$,

D = internal diameter of shell in mm.,

K = 40 for Class 1 vessels,

= 35 for Class 2 vessels with shells 16 mm. thick and above,

= 32,5 for Class 2 vessels with shells less than 16 mm. thick.

**2304** For Class 1 pressure vessels operating at metal temperatures exceeding 343° C. the thickness of cylindrical shells is to be determined by the appropriate formula of J 1602 in association with the permissible stresses at temperature of Table 1 for carbon and carbon-manganese steel.

### Material

**2305** The material used in the construction of pressure vessels is to be manufactured and tested in accordance with the relevant requirements of Chapter P.

The tensile strength of the material is to be between 38 and 47 kg. per mm.$^2$ with a range not exceeding 6,3 kg. per mm.$^2$ in any one case.

### Preliminary Conditions and Tests for Class 1 Forge Welding

**2306** In order that the name of a firm may be included in the list of firms recognised by the Committee for the manufacture of Class 1 forge welded pressure vessels, it will be necessary for the Surveyors to make a preliminary visit to the works for the purpose of inspecting the welding plant, equipment and procedure, also to arrange for the carrying out of a special series of tests as described in 2309. Subsequently the Surveyors will report periodically to the Committee on the conditions which obtain at the works, and if considered necessary will carry out further tests.

**2307** The welding plant and equipment are to be of good quality and maintained in efficient working condition. The welding plant is to be installed under cover and arranged so that the welding work may be carried out in positions free from draughts and adverse weather conditions. The procedure is to be such that there is regular and systematic supervision of the welding work.

**2308** The works should be equipped with an efficient testing laboratory which should include apparatus suitable for carrying out tensile, bend and impact tests, and micro-examination. The works should also be equipped with a suitable heat treating furnace having satisfactory means for temperature control, but as an alternative, arrangements may be made whereby pressure vessels can be heat treated elsewhere.

**2309** A series of special preliminary tests to demonstrate the quality of the welding work is to be carried out. The tests should include tensile, bend, impact, hardness and fatigue tests on specimens which should be prepared in a similar manner to that used in the making of longitudinal joints in pressure vessels. The Surveyors are to select portions of the test plates from which photomicrographs, at 100 and 300 magnifications, are to be prepared representing the weld centre and the plate remote from the weld.

**2310** A full size pressure vessel is to be manufactured under survey, and is to comply in every respect with the requirements for Class 1 forge welded pressure vessels.

**2311** In the case of firms of large experience some modification may be permitted in regard to the requirements of 2309, provided satisfactory evidence is produced of successful results obtained by the firm's welding methods, over an appreciable period.

### Routine Tests for Forge Welded Pressure Vessels

#### Class 1

**2312** The shell plates of each pressure vessel are to be left long enough to accommodate the following test specimens:—

Two tensile specimens, } with provision
Four bend specimens, } for retests.

#### Retests

**2313** If any of the tests fail, two retests are to be made, both of which are to comply fully with the test requirements.

#### Tensile Test

**2314** The tensile specimens are to conform to the standard test piece A (*see* P 312), and the mid portion of the specimens is to coincide with the centre line of the weld.

The ultimate tensile strength of both test pieces is to be not less than 95 per cent of the minimum specified for the plate material. The elongation is to be not less than 18 per cent on a gauge length of 200 millimetres.

#### Bend Tests

**2315** The width of the bend specimens is to be not less than 1,5 times the thickness, and the mid portion of the specimens is to coincide with the centre line of the weld. Two specimens are to be bent in such a manner that the outer surface of the weld is in tension, and two specimens are to be bent with the outer surface of the weld in compression.

In both cases the specimens are to be bent without fracture through 180 degrees round a former, the diameter of which is not greater than three times the thickness of the specimen.

NOTE:—Some modification of the requirements contained in 2312 may be permitted in circumstances such as are indicated in 2311.

#### Test Pieces for Circumferential Seams

**2316** In the case of pressure vessels having circumferential joints only, no test pieces need be provided unless the internal diameter of the pressure vessel exceeds 1370 mm., when a representative welded joint is to be made and cut up to provide the specimens detailed above.

#### Class 2

**2317** In the case of forge welded pressure vessels other than those included in Class 1, routine tests are not required in respect of longitudinal joints, but where the

internal diameter of a pressure vessel exceeds 1370 mm. the manufacturer is to produce authoritative evidence of test results demonstrating that efficient circumferential welds of the proposed dimensions can be made consistently.

### Weld Thickness

**2318** On completion of the welding the thickness at and adjacent to the weld is to be not less than the required thickness of the shell plate as determined from the formulæ for working pressure given in J 1602, J 1603 and J 1815.

### Heating

**2319** The heating of plates for welding is to be carried out by means of a process which will provide a flame which will not be of an oxidizing character and will not tend to introduce impurities into the steel. Provision is to be made for careful control of the welding heat.

### Heat Treatment

**2320** All forge welded pressure vessels are to be efficiently normalised by heating uniformly to a temperature of 920° C. (1690° F.) and allowed to cool in still air.

The heat treatment is to be carried out in accordance with the requirements of J 1925 to J 1929, so far as these are applicable.

### Hydraulic Test

**2321** Pressure vessels are to be subjected to a hydraulic test pressure of twice the working pressure. Whilst under this test the pressure vessel is to be well hammered on both sides of, and close to, the welded seams.

## Section 24

### AIR RECEIVERS

**2401** Cylindrical receivers for containing air under high pressure may be made either of seamless steel or of welded, or riveted, steel plates.

### Welded Receivers

**2402** Receivers of fusion or forge welded construction are to comply with the requirements of J 18 to J 23.

### Riveted Receivers

**2403** Receivers of riveted construction are to comply with the Rules for cylindrical boilers, where applicable.

### Dished End Plates

**2404** Where end plates are dished to partially spherical form and not fitted with stays, the scantlings may be determined by the following formula:—

$$WP = \frac{C \times S \times T}{R}$$

where WP = working pressure, in kg. per cm.$^2$

C = 25,7 for ends concave to pressure,

= 16,5 for ends convex to pressure,

S = minimum tensile strength of the plates, in kg. per mm.$^2$

T = thickness of the end, in mm. after dishing,

R = inside radius of curvature of the end, in mm. which is not to exceed the diameter of the shell.

Ends convex to pressure are not to be used for receivers exceeding 610 mm. internal diameter.

If desired the formula J 1605 may be used in determining the scantlings of dished ends subject to pressure on the concave side.

The inside corner radius is to be not less than four times the thickness of the end plate and in no case less than 64 mm.

Where the end is provided with a flanged manhole the thickness of the end, in mm. determined by the foregoing formula is to be increased by 3 mm. and the depth (F) of the manhole flange, measured in mm. from the outer surface at the minor axis is to be not less than

$$F = \sqrt{T_1 \times W}$$

where $T_1$ = required thickness of the end plate, in mm.

W = minor axis of the manhole, in mm.

### Seamless Receivers

**2405** The material used is to comply with the requirements of P 322.

**2406** The permissible working pressure for seamless receivers is to be determined by the following formulæ:—

$$WP = \frac{C \times S \times (t - 3{,}2)}{D}$$

for thicknesses of 16 mm. and above.

$$WP = \frac{C \times S \times (t - 1{,}6)}{D}$$

for thicknesses below 16 mm.

where WP = working pressure, in kg. per cm.$^2$,

S = minimum tensile strength of the steel shell plates, in kg. per mm.$^2$,

t = thickness of the shell plates, in millimetres,

D = internal diameter, in millimetres,

C = 55 for receivers of thickness 16 mm. and above,

49 for receivers of thickness below 16 mm.

**2407** Each seamless receiver is to be carefully annealed after manufacture, and before the hydraulic test.

### Hydraulic Test

**2408** Each seamless receiver is to be subjected to a hydraulic test of twice the working pressure, which it is to withstand without permanent set.

**2409** Each receiver made of riveted steel plates for pressures up to 21 kg. per cm.$^2$ is to be tested by hydraulic pressure to 1,5 times the working pressure, plus 3,5 kg. per cm.$^2$ Where higher working pressures are used, the test pressure need not be more than 14 kg. per cm.$^2$ above the working pressure.

### General

**2410** All receivers above 150 mm. internal diameter are to be so made that the internal surfaces may be examined and, wherever practicable, the openings for this purpose are to be sufficiently large for access. Means are to be provided for cleaning the inner surfaces by steam, or otherwise.

**2411** Each receiver which can be isolated from a safety valve is to be provided with a suitable fusible plug to discharge the contents in case of fire.

**2412** Each receiver is to be fitted with a drain arrangement at its lowest part, permitting oil and water to be blown out.

### Cross-reference

**2413** For scantlings of compressed air pipes, *see* E 506 and E 512.

### Periodical Surveys

**2414** For periodical survey requirements, *see* Chapter C.

## Section 25

## PRESSURE VESSELS FOR THE CARRIAGE OF LIQUEFIED PETROLEUM GASES

### General

**2501** The requirements of this Section are applicable to welded steel pressure vessels of cylindrical or spherical form intended for the carriage of liquefied petroleum gas under pressure at ambient or lower temperatures. The vessels should be constructed generally in accordance with the Rules for Welded Pressure Vessels Class 1 and installed in closed holds with the vessels and their mountings protruding above the weather deck.

*See* E 12 for requirements for filling, discharging, venting and inerting pipe arrangements, tank connections and mountings, cargo pumps and compressors and other associated equipment.

*See* D 70, D 71 and D 72 for ship requirements for the carriage of liquefied gases.

### Plans

**2502** Before construction of the vessels is commenced the following particulars where applicable and plans are to be submitted for approval:—

(1) Nature of cargoes, together with maximum vapour pressure and minimum liquid temperature for which the pressure vessels are to be approved, and proposed hydraulic test pressure.

(2) Particulars of materials proposed for the construction of the vessels. (*See* 2503.)

(3) Particulars of refrigeration equipment.

(4) General arrangement plan showing location of pressure vessels in the ship.

(5) Plan of pressure vessel showing attachments, openings, dimensions, details of welded joints and particulars of proposed stress relief heat treatment.

(6) Plan of seatings, securing arrangements and deck sealing arrangements.

(7) Plan showing arrangement of mountings, level gauges and number, type and size of safety valves.

### Materials

**2503** Plate materials are to be manufactured and tested in accordance with the requirements of P 3 and the specification of the material is to be submitted for approval as

required by P 307 for steels operating at low metal temperatures. In addition to the tensile and bend test requirements the tests of plates at the steel works are to include Charpy V-notch impact tests at the design metal temperature.

For pressure vessels where the carrying temperature is 0° C. or less, specifications of the weld metal as well as the plate material, including Charpy V-notch impact properties at the carrying temperatures, are to be submitted for approval. For pressure vessels where the cargo is carried at atmospheric temperature the plate material is to have minimum impact properties of 4,84 kgm. at 0° C. For details of impact tests *see* P 207 and P 208. Tests to determine the impact strength of weld metal should have regard to variations in welding positions.

### Design

**2504** For pressure vessels where the cargo is carried at atmospheric temperature, the vapour pressure used for design purposes is to be not less than the vapour pressure of the liquefied gas at 45° C.

The thickness at any part of the pressure vessel is not to be less than determined by the formulae in J 1815 and J 1816 for a working pressure appropriate to the vapour pressure and static liquid head. The thickness so obtained is to be increased where necessary to take account of the following:—

(a) local stresses in shell and ends due to reactions from seatings and securing fitments when the ship is upright or listed up to 30°,

(b) thermal expansion and contraction effects where the liquid cargo is to be carried at temperatures below ambient,

(c) dynamic loading from rolling, pitching and heaving of the ship in a seaway to the extent given in D 7116. Alternatively, provision for dynamic loading can be made by assuming that pressures due to static head are doubled.

The sum of all stresses due to static and dynamic loading is not to exceed one third of the tensile strength of the material.

Special attention is to be given to the design of attachments welded to the pressure vessel for supporting or securing purposes so as to minimise stress concentrations at these points.

Seatings are to be so designed as to ensure adequate and uniform support to the pressure vessel having due regard to deflections of the hull structure in a seaway.

All valves, fittings and manholes are to be located on that portion of the pressure vessel which protrudes above the weather deck, and are to be protected from damage and corrosion. Manholes should be placed above the liquid level. Valves and fittings are to be of steel or other approved ductile material.

The sealing arrangements at deck are to provide for expansion and contraction of the vessel under normal operating pressure and temperature and are to be watertight.

Suitable arrangements are to be made to prevent the pressure, temperature and liquid level in the tanks from rising above safe limits. Details are to be submitted; also it should be stated whether the safety arrangements are controlled by statutory requirements of any National Authority.

### Refrigeration Equipment

**2505** Where refrigeration equipment is installed, two or more refrigerating units are to be provided of capacity sufficient to maintain the liquid cargo at the carrying temperature with any one unit out of use. (*See* E 1228.)

### Construction and Tests

**2506** In general, pressure vessels are, so far as practicable, to be constructed and tested to the Rules for Class 1 Welded Pressure Vessels, except that the work may be carried out by manufacturers not appearing on the Society's Class 1 List, provided fabrication and tests are completed to the satisfaction of the Surveyors.

Some relaxation of Class 1 requirements as regards tests and heat treatment may be permitted dependent on design, scantlings and material of the vessel, but generally, welded joints should be subjected to radiographic examination. Where the pressure vessels are too large for furnace stress relief, proposals for local stress relief and stress relief of prefabricated components will be considered.

Where plates are hot formed to shape, check tests including impact tests are to be made on the material as required in P 310. Where a large number of plates are involved, check tests on selected plates will suffice, provided the Surveyor is satisfied that the hot forming process is closely controlled.

For pressure vessels where the operating metal temperature is 0° C. or less, provision is to be made for Charpy V-notch impact tests of the welded joints in addition to the other tests specified in J 1916. Test pieces are to be cut transverse to the direction of the weld and the notches are to be located in the weld metal normal to the plate surface. Not less than 3 test pieces are required from each test plate. The impact tests are to be made at the carrying

temperature for which the vessel is approved and the test results are to comply with approved specification. (*See* 2503.)

### Hydraulic Tests

**2507** The pressure vessel is to be tested as required by J 1930 but the hydraulic test pressure is to be 1,5 times the design pressure for the weakest part of the vessel. The static head of the water may be included in the test pressure if the amount is significant.

On completion, the vessels are to be clearly marked with the maximum vapour pressure and minimum carrying temperature.

*21st May, 1964*

# APPENDIX

## Firms recognised by the Committee for the Manufacture of Class 1 Welded Pressure Vessels.

**Note**: The Society's Office giving attendance at the Works is shown in brackets.

### FUSION WELDING

**United Kingdom**

Adamson, D., Hatchett & Co., Ltd., Dukinfield, Cheshire. (Manchester.)

Adamson, Joseph, & Co., Ltd., Hyde, Cheshire. (Manchester.)

Aiton & Co., Ltd., Derby. (Nottingham.)

Ashmore, Benson, Pease & Co., Ltd., South Works, Stockton-on-Tees. (Middlesbrough.)

Babcock & Wilcox, Ltd., Renfrew. (Glasgow.)

Balfour, Henry, & Co., Ltd., Leven, Fife. (Leith.)

Brown, John, & Co., Ltd., Clydebank. (Glasgow).

Brown, John, Land Boilers Ltd., Whitecrook Works, Clydebank. (Glasgow.)

Butterfield, W. P. (Engineers) Ltd., P.O. Box No. 38, Shipley, Yorks. (Leeds.)

Cammell Laird & Co. (Shipbuilders & Engineers), Ltd., Birkenhead. (Liverpool.)

Clark, Geo., (Sunderland) Ltd., Southwick Eng. Works. (Sunderland.)

Clarke, Chapman & Co., Ltd., Gateshead. (Newcastle.)

Clayton, Son & Co., Ltd., Pepper Road Works and Moor End Works, Hunslet, Leeds, 10. (Leeds.)

Cochran & Co., Annan, Ltd., Annan. (Glasgow.)

Danks, Edwin & Co., (Oldbury) Ltd. (Birmingham.)

Danks of Netherton Ltd., Netherton. (Birmingham.)

Davey, Paxman & Co., Ltd., Standard Ironworks, Colchester, Essex. (London.)

English Electric Co., Ltd., Netherton Works, Netherton, Lancs. (Liverpool.)

English Electric Co., Ltd., Stafford. (Birmingham.)

Farrar Boilerworks Ltd., Newark-on-Trent. (Nottingham.)

Firth Brown, Ltd., Atlas Works, Sheffield. (Sheffield.)

Foster, Yates & Thom, Ltd., Canal Works, Blackburn. (Manchester.)

Grazebrook, M. & W., Ltd., Dudley, Worcestershire. (Birmingham.)

Harland & Wolff, Ltd., Belfast. (Belfast.)

Harvey Fabrication, Ltd., London, S.E.7. (London.)

Head Wrightson Teesdale, Ltd., Thornaby-on-Tees. (Middlesbrough.)

Horseley Bridge & Thomas Piggott, Ltd., Tipton, Staffs. (Birmingham.)

International Combustion Ltd., Derby. (Nottingham.)

Jenkins, Robert, & Co., Ltd., Rotherham. (Sheffield.)

Markham & Co., Ltd., Broad Oaks Works, Chesterfield. (Sheffield.)

Marshall & Anderson, Ltd., Manse Road, Motherwell. Works: Broomside. (Glasgow.)

Marshall, Sons & Co., Ltd., Britannia Works, Gainsborough. (Sheffield.)

McLaren Fabrications Ltd., Leathley Road, Leeds, 10. (Leeds.)

Millspaugh, Ltd., Sheffield. (Sheffield.)

Motherwell Bridge & Engineering Co. Ltd., Motherwell. (Glasgow.)

Newton Chambers & Co., Ltd., Thorncliffe, Nr. Sheffield. (Sheffield.)

North Eastern Marine Engineering Co., Ltd., Wallsend. (Newcastle.)

Penman & Co. Ltd., Glasgow. (Glasgow.)

Redheugh Iron & Steel Co., Ltd., Teams, Gateshead, Co. Durham. (Newcastle.)

Robey & Co., Ltd., Globe Works, Lincoln. (Nottingham.)

Ruston & Hornsby, Ltd., Lincoln. (Nottingham.)

Steels Process Plants Ltd., Crown Works, Sunderland. (Sunderland.)

Stephen, Alexander, & Sons, Ltd., Glasgow. (Glasgow.)

Thompson, John (Wolverhampton) Ltd., Wolverhampton. (Birmingham.)

Towler & Son, Ltd., London, E.15. (London.)

Vickers-Armstrongs (Engineers) Ltd., Elswick Works, Newcastle upon Tyne. (Newcastle.)

Watson, Robert, & Co. (Constructional Engineers), Ltd., Bolton, Lancs. (Manchester.)

Weir, G. & J., Ltd., Cathcart, Glasgow. (GLASGOW.)
Whessoe Ltd., Darlington. (MIDDLESBROUGH.)
Wrights Forge & Engineering Co., Ltd., Tipton, Staffs. (BIRMINGHAM.)
Yarrow & Co. Ltd., Scotstoun, Glasgow. (GLASGOW.)

**Australia**

Babcock & Wilcox of Australia Pty. Ltd., Regents Park, N.S.W. (SYDNEY.)
Cockatoo Docks & Engineering Co., Pty. Ltd., Sydney, N.S.W. (SYDNEY.)
Commonwealth Ordnance Factory, Maribyrnong, Victoria. (MELBOURNE.)
Perry Engineering Co., Ltd., Adelaide, S. Australia. (ADELAIDE.)
Smith, Bernard, Pty. Ltd., Sydney, N.S.W. (SYDNEY.)
Thompsons (Castlemaine) Ltd., Melbourne, Victoria. (MELBOURNE.)
Tomlinson Steel Ltd., Perth, Western Australia. (FREMANTLE.)

**Austria**

Vereinigte Osterreichische Eisen-und-Stahlwerke Aktiengesellschaft, Linz an der Donau. (VIENNA.)
Waagner-Biro Aktiengesellschaft, Graz, Styria. (VIENNA.)

**Belgium**

Chaudronneries Pierre Brouhon, S.A., Awans-Bierset-lez-Liege. (ANTWERP.)
Cockerill-Ougrée, S.A., Seraing. (ANTWERP.)

**Canada**

Babcock, Wilcox & Goldie McCulloch Ltd., Galt, Ontario. (TORONTO.)
Canadian General Electric Co., Ltd. (Canadian Allis-Chalmers Ltd.), Davenport Works, Toronto. (TORONTO.)
Canadian Vickers Ltd., Montreal. (MONTREAL.)
Davie Shipbuilding Ltd., Lauzon, P.Q. (QUEBEC.)
Dominion Bridge Co., Ltd., Lachine, Quebec. (QUEBEC.)
Foster Wheeler Ltd., St. Catharines, Ontario. (TORONTO.)
Inglis, John, & Co., Ltd., Toronto. (TORONTO.)
Vancouver Iron Works Ltd., Vancouver, B.C. (VANCOUVER.)

**Denmark**

Aalborg Vaerft A/S, Aalborg. (AALBORG.)
Burmeister & Wain A/S, Copenhagen. (COPENHAGEN.)
Helsingor Skibsvaerft & Maskinbyggeri, Elsinore. (COPENHAGEN.)

**Finland**

Valmet Oy, Rautpohjan tehdas, Jyvaskyla. (ABO.)
Wartsila-Koncernen A/B, Maskin och Bro, Helsingfors. (HELSINGFORS.)

**France**

Ateliers & Chantiers de Nantes (Bretagne-Loire). (NANTES.)
Ateliers & Chantiers de la Seine Maritime, Le Trait. (ROUEN.)
Brissonneau & Lotz, Nantes. (NANTES.)
Chantiers de l'Atlantique (Penhoët-Loire), St. Nazaire. (NANTES.)
Compagnie de Fives-Lille, Fives-Lille, Nord. (VALENCIENNES.)
Soc. Française des Constructions Babcock & Wilcox, La Courneuve (Seine). (PARIS.)

**Germany**

Borsig A.G., Berlin-Tegel. (BERLIN.)
Bremer Vulkan, Bremen-Vegesack. (BREMEN.)
Deutsche Babcock & Wilcox Dampfkesselwerke A.G., Oberhausen. (DUSSELDORF.)
Deutsche Werft A.G., Hamburg. (HAMBURG.)
Dinglerwerke A.G., Zweibruecken, Werke in Zweibruecken und Bierbach-Saar. (SAARBRUCKEN-SAAR.)
Gutehoffnungshütte Oberhausen A.G., Werke Sterkrade, Oberhausen-Sterkrade. (DUSSELDORF.)
Howaldtswerke A.G., Kiel. (KIEL.)
Klöckner-Werke A.G. Georgsmarienwerke, Osnabrück. Werk Georgsmarienhütte. (HANOVER.)
Koerver & Lersch, Krefeld. (DUSSELDORF.)
Krupp, Fried., Maschinenfabriken, Essen. (DUSSELDORF.)
Mannesmann Hüttenwerke A.G., Duisburg-Huckingen. (DUSSELDORF.)
Maschinenfabrik Augsburg-Nürnberg A.G., Augsburg. (AUGSBURG.)
Maschinenfabrik Augsburg-Nürnberg A.G., Gustavsburg. (MANNHEIM.)
Maschinenfabrik Augsburg-Nürnberg A.G., Werk Hamburg, Hachmannkai, Hamburg 11. (HAMBURG.)
Phoenix-Rheinrohr A.G., Mulheim, Ruhr. (DUSSELDORF.)
Pintsch-Bamag A.G., Alteburgerstr. 300, Koln-Bayenthal. (KOLN.)
Rheinstahl Huettenwerke A.G., Werk Ruhrstahl Henrichshuette, Hattingen-Ruhr. (DORTMUND.)
Siller & Jamart, Wuppertal Barmen. (DUSSELDORF.)
Stahl-und-Röhrenwerke Reisholz A.G., Dusseldorf-Reisholz. (DUSSELDORF.)

Steinmuller, L. & C., G.m.b.H., Gummersbach/Rhld. (HAMBURG.)
Weser A.G., Bremen. (BREMEN.)

**Holland**

"Breda" N.V. Machinefabrik, v/h Backer & Rueb, Rotterdam. (ROTTERDAM.)
Bronswerk-Amaf., Amersfoort. (AMSTERDAM.)
Dok-en Werf-Maatschappij Wilton-Fijenoord N.V., Schiedam. (ROTTERDAM.)
Jonker N.V. Hk., & Zoon, Amsterdam. (AMSTERDAM.)
Kon. Mij. "De Schelde" N.V., Vlissingen. (ROTTERDAM.)
Nederlandsche Dok en Scheepsbouw Mij. (AMSTERDAM.)
Nederlandsche Electrolasch Mij. N.V., Leiden. (ROTTERDAM.)
Rotterdamsche Droogdok Maatschappij N.V., Rotterdam. (ROTTERDAM.)
Stork, Gebr., & Co. N.V., Hengelo. (AMSTERDAM.)
Werkspoor, N.V., Amsterdam. (AMSTERDAM.)

**Italy**

Acciaieria & Tubificio di Brescia, Brescia. (GENOA.)
Ansaldo Stabilimento Meccanico, Genoa. (GENOA.)
Bonaldi, D. & Co. S.p.A., Crema. (MILAN.)
Cantieri Riuniti dell' Adriatico. (TRIESTE.)
C.I.P.I. Costruzioni Impianti Petroliferi Industriali, Marghera, Venice. (Also known as Guido Sartori.) (VENICE.)
Franco Tosi S.p.A., Legnano. (GENOA.)
Nuovo Pignone, Industrie Meccaniche e Fonderia S.p.A., Stabilimento di Massa, Apuania. (GENOA.)
Terni, Società per l'Industria e l'Elettricità, Terni. (NAPLES.)

**Japan**

Babcock-Hitachi K.K., Yokohama. (YOKOHAMA.)
Fuji Denki Seizo K.K., Kawasaki Works, Kawasaki. (YOKOHAMA.)
Fujinagata Shipbuilding & Engineering Co. Ltd., Osaka. (KOBE.)
Hitachi Ltd., Hitachi Works, Ibaragi-Ken. (YOKOHAMA.)
Hitachi Ltd., Kure Works, Kure. (SHIMONOSEKI.)
Hitachi Shipbuilding & Eng. Co., Ltd., Innoshima Shipyard, Innoshima. (KOBE.)
Hitachi Shipbuilding & Eng. Co., Ltd., Sakurajima Shipyard, Osaka. (KOBE.)
Ishikawajima-Harima Heavy Industries Co., Ltd., Aioi. (KOBE.)
Ishikawajima-Harima Heavy Industries Co., Ltd., Nagoya Shipyard. (KOBE.)
Ishikawajima-Harima Heavy Industries, Co., Ltd., Tokyo. (YOKOHAMA.)
Ishikawajima Shibaura Turbine Co., Ltd., Tsurumi Works, Yokohama. (YOKOHAMA.)
Kawasaki Dockyard Co., Ltd., Kobe. (KOBE.)
Kobe Steel Works Ltd., Okubo Plant, Akashi City. (KOBE.)
Maizuru Dockyard, Iino Sangyo Kaisha Ltd., Amarube, Maizuru. (KOBE.)
Mitsubishi Heavy Industries, Ltd., Nagasaki Shipyard & Engine Works, Nagasaki. (NAGASAKI.)
Mitsubishi Shipbuilding & Engineering Co., Ltd., Hiroshima. (HIROSHIMA.)
Mitsui Shipbuilding & Engineering Co., Ltd., Tamano. (KOBE.)
Nippon Steel Tube Co., Tsurumi. (YOKOHAMA.)
Shin Mitsubishi Heavy-Industries Ltd., Kobe. (KOBE.)
Uraga Shipbuilding Yard, Uraga Dock Co., Ltd., Yokosuka. (YOKOHAMA.)
Yokohama Shipyard & Eng. Works, Mitsubishi Nippon Heavy Industries Ltd., Yokohama. (YOKOHAMA.)
Yokoyama Engineering Co., Ltd., Kawasaki Works, Kawasaki. (YOKOHAMA.)

**Norway**

Elektrisk Sveisning A/S, Toyenbekken 34, Oslo. (OSLO.)
Fredriksstad Mek. Verksted, Fredrikstad. (OSLO.)

**Poland**

Huta Ferrum, Katowice. (GDANSK.)
Stocznia Gdansk (Shipbuilding, Marine Engineering & Boiler Works), Gdansk. (GDANSK.)

**South Africa**

Thompson, John, Africa (Pty.), Ltd., Bellville, Cape Province. (CAPE TOWN.)
Vanderbijl Engineering Corporation Ltd., Duncanville Works, Houtkop Road, Duncanville. (VEREENIGING.)
Vanderbijl Engineering Corporation Ltd., Vecor Works, Vanderbijl Park, N.W.7, Transvaal. (VEREENIGING.)

**Spain**

Empresa Nacional Bazan, El Ferrol. (BILBAO.)
La Maquinista Terrestre y Maritima S.A., Barcelona. (BARCELONA.)

**Sweden**

Aktiebolaget Gotaverken, Gothenburg. (GOTHENBURG.)
Avesta Jernverks A/B, Avesta. (STOCKHOLM.)
Broderna Hedlund A/B, Stockholm. (STOCKHOLM.)

Eriksbergs Mek. Verkstads A/B, Gothenburg. (GOTHENBURG.)
Karlskronavarvet A.B., Karlskrona. (MALMO.)
Landsverk A/B, Landskrona. (HELSINGBORG.)
Lindholmens Varv. A/B, Gothenburg. (GOTHENBURG.)
Motala Verkstad A/B, Motala. (GOTHENBURG.)
Pullmax A/B, Gothenburg. (GOTHENBURG.)
Svenska Maskinverken A/B, Kallhall Works. (STOCKHOLM.)
Uddeholms Aktiebolag, Degerfors Jernverk, Degerfors. (GOTHENBURG.)

**Switzerland**

Brown Boveri Ltd., Baden. (WINTERTHUR.)
Sulzer Brothers Ltd., Winterthur. (WINTERTHUR.)

**U.S.A.**

Babcock & Wilcox Co., Barberton, Ohio. (CLEVELAND.)
Bethlehem Steel Co., Bethlehem, Pa. (PHILADELPHIA.)
Bethlehem Steel Co., Shipbuilding Division, Quincy Works, Mass. (BOSTON.)
Chicago Bridge & Iron Co., Birmingham, Alabama. (MOBILE.)
Combustion Engineering Co. Inc., New York.
Works at Chattanooga, Tennessee. (MOBILE.)
Works at St. Louis. (PHILADELPHIA.)
Downington Iron Works Inc., Downington, Pa. (PHILADELPHIA.)
Erie City Iron Works, Erie, Pa. (CLEVELAND).
Farrar & Trefts Inc., Buffalo, N.Y. (CLEVELAND.)
Foster Wheeler Corporation, Carteret, N.J. (NEW YORK.)
Foster Wheeler Corporation, Mountaintop, Pa. (PHILADELPHIA.)
Griscom-Russel Co., Massillon, Ohio. (CLEVELAND.)
Johnston Brothers Inc., Ferrysburg, Michigan. (CLEVELAND.)
Smith, A. O., Corporation, Milwaukee, Wisconsin. (NEW YORK.)
Sun Shipbuilding & Dry Dock Co., Chester, Pa. (PHILADELPHIA.)

**Yugoslavia**

Tvornica Parnih Kotlova, Zagreb. (RIJEKA.)

## FORGE WELDING

Thompson, John, (Wolverhampton) Ltd., Wolverhampton. (BIRMINGHAM.)

*October, 1964*

1965.

# Chapter K

# SPARE GEAR FOR STEAM AND INTERNAL COMBUSTION MACHINERY INSTALLATIONS

FOR THE EFFICIENT OPERATION OF THE SHIP THE FOLLOWING ARTICLES OF SPARE GEAR, SO FAR AS THEY ARE APPLICABLE, SHOULD BE SUPPLIED. OWNERS SHOULD ARRANGE TO REPLACE OR MAKE GOOD USED ITEMS AS OPPORTUNITY OCCURS.

| ITEM NO. | ITEM | SPARE PARTS REQUIRED TO BE SUPPLIED | | |
|---|---|---|---|---|
| | | NUMBER REQUIRED FOR | | SPARE PART |
| | | OCEAN GOING SHIPS | SHORT VOYAGE SHIPS | |
| | **MAIN PROPELLING MACHINERY** | | | |
| | STEAM RECIPROCATING ENGINES (*See also* items 20 and 21) | | | |
| 1 | Connecting Rod Bearings | 1 | 1 | Bottom end bearing complete with liners, bolts and nuts. |
| | | 1 | 1 | Top end bearing complete with liners, bolts and nuts for one connecting rod. |
| 2 | Piston Rings | 1 set | 1 set | Rings and springs for H.P. Piston. |
| 3 | Piston Valve Rings | 1 set | — | Rings and springs, of each size used. |
| 4 | Piston Rod Metallic Packing | 1 | — | Complete set of packing for H.P. piston rod and valve spindle. |
| 5 | Poppet Valves | 1 | — | Valve complete with cage, spindle and bush, of each size used, together with rollers and springs. |
| | STEAM TURBINES (*See also* items 20 and 21) | | | |
| 6 | Bearing Bushes | 1 | — | Complete bearing bush, of each size and type used, for the rotor, pinion and gear wheel shafts, for one engine. |
| 7 | Turbine Thrust | 1 set | 1 set | Pads of each size for one face of Michell type thrust, or rings for turbine adjusting block, of each size used for one engine.<br>Assorted liners for 1 block where fitted. |
| | OIL ENGINES (*See also* items 20 and 21) | | | |
| 8 | Valves | 2 | 2 | Exhaust valves complete with valve casings, springs and other fittings. |
| | | 1 | 1 | Air inlet valve complete with valve casing, springs and other fittings. |
| | | 1 | 1 | Starting air valve on cylinder complete with valve casing, springs and other fittings. |
| | | ½ set | ½ set | Fuel valves, of each size and type used, complete with all fittings, for one engine. |
| | | 1 | 1 | Cylinder relief valve complete. |

| ITEM NO. | ITEM | SPARE PARTS REQUIRED TO BE SUPPLIED | | |
|---|---|---|---|---|
| | | NUMBER REQUIRED FOR | | SPARE PART |
| | | OCEAN GOING SHIPS | SHORT VOYAGE SHIPS | |
| 9 | Piston (including piston exhaust valves where used) | 1 | — | *Crosshead Type.* Piston, of each size used, complete with rings, studs and nuts. |
| | | 1 | — | *Trunk Piston Type.* Piston of each size used, complete with skirt, rings, studs, nuts and gudgeon pin. |
| 10 | Piston Rings (including rings for piston exhaust valves where used) | 1 set | 1 set | Rings, of each size used, for one cylinder. |
| 11 | Piston Cooling Pipes | 2 sets | 1 set | Telescopic cooling pipes and fittings or their equivalent, for a cylinder unit. |
| 12 | Connecting Rod Bearings | 1 | 1 | Bottom end bearing of each type fitted complete with liners, bolts and nuts. |
| | | 1 | — | Top end bearing of each type fitted complete with liners, bolts and nuts. |
| | | 1 | 1 | Gudgeon pin bush, where trunk pistons are used. |
| 13 | Scavenge Blower<br>NOTE : Where there are two scavenge blowers connected to all cylinders, spare gear may be omitted provided the engines can manœuvre satisfactorily when one of the blowers is not in action. | 1 set | — | Rotors, rotor shafts, bearings and synchronising gear wheels or equivalent working parts if of other types. |
| 14 | Valves for Scavenge System | ½ set | ½ set | Suction and delivery valves, for one engine. |
| 15 | Gear and Chain Drives for Camshafts, Scavenge Blowers, Compressors, Fuel Pumps, Cooling Water Pumps, Bilge Pumps and Lubricating Oil Pumps (excluding cylinder lubricators). | 1 set | — | *Gear Wheel Drive.* Wheels for the drive of one engine. |
| | | 6 | — | *Chain Drive.* Separate links with pins and rollers of each size used. |
| 16 | Fuel Pumps | 1 | 1 | One pump unit complete where a separate pump is provided for each cylinder,<br>or<br>One complete set of working parts for one pump where several pumps are grouped in one body, plus one body. |
| 17 | Reduction and/or Reverse Gear Case Bearing Bushes | 1 | — | Complete bearing bush, of each size fitted in the gear case assembly. |
| | | 1 | — | Roller or ball race, of each size fitted in the gear case assembly. |
| 18 | Main Engine Driven Air Compressor | 1 set | 1 set | Piston rings of each size used. |
| | | ½ set | ½ set | Suction and delivery valves complete, of each size used. |
| 19 | Fuel Pipes | 1 | 1 | Length of pipe of the greatest length used, complete with flanges or unions, for the fuel delivery to the cylinders. |

| ITEM NO. | ITEM | SPARE PARTS REQUIRED TO BE SUPPLIED | | |
|---|---|---|---|---|
| | | NUMBER REQUIRED FOR | | SPARE PART |
| | | OCEAN GOING SHIPS | SHORT VOYAGE SHIPS | |
| | APPLICABLE TO ALL TYPES OF MAIN ENGINES | | | |
| 20 | Main Thrust Blocks | 1 set | 1 set | Pads for one face of Michell type thrust block |
| | | | | or |
| | | 1 | 1 | Complete white metal thrust shoe of solid ring type |
| | | | | or |
| | | 1 | 1 | Inner and outer race with rollers where roller thrust bearings are used. |
| 21 | Coupling Bolts | 1 set | — | Bolts, of each size used, for one coupling. |
| | ELECTRIC PROPELLING MACHINERY | For items of spare gear to be carried *see* M 20. | | |

## AUXILIARY MACHINERY

Where additional units of adequate capacity are fitted no spare gear is required.

| | | | | |
|---|---|---|---|---|
| | AUXILIARY OIL ENGINES | For each size of engine required for essential services. | | |
| 22 | Valves | 2 | 2 | Exhaust valves complete with valve casings, springs and other fittings. |
| | | 1 | 1 | Air inlet valve, complete with valve casing, springs and other fittings. |
| | | 1 | 1 | Starting air valve on cylinder complete with valve casing, springs and other fittings. |
| | | ½ set | ¼ set | Fuel valves of each size used, complete with all fittings, for one engine. |
| | | 1 | 1 | Cylinder relief valve complete. |
| 23 | Piston Rings | 1 set | 1 set | Rings of each size used, for one cylinder. |
| 24 | Piston Cooling Pipes | 2 sets | 1 set | Telescopic cooling pipes and fittings or their equivalent, for a cylinder unit. |
| 25 | Connecting Rod Bearings | 1 | 1 | Bottom end bearing of each type fitted complete with liners, bolts and nuts. |
| | | 1 | 1 | Gudgeon pin bush, where trunk pistons are used. |
| 26 | Valves for Scavenge System | ¼ set | ¼ set | Suction and delivery valves, for one engine. |
| 27 | Fuel Pumps | 1 | 1 | One pump unit complete where a separate pump is provided for each cylinder, or One complete set of working parts for one pump where several pumps are grouped in one body, plus one body. |
| 28 | Fuel Pipes | 1 | 1 | Length of pipe of the greatest length used, complete with flanges or unions, for the fuel delivery to the cylinders. |

| ITEM NO. | ITEM | SPARE PARTS REQUIRED TO BE SUPPLIED | | |
|---|---|---|---|---|
| | | NUMBER REQUIRED FOR | | SPARE PART |
| | | OCEAN GOING SHIPS | SHORT VOYAGE SHIPS | |
| | AUXILIARY STEAM ENGINES | For each size of engine required for essential services. | | |
| 29 | Connecting Rod Bearings | 1 | 1 | Bottom end bearing complete with liners, bolts and nuts. |
| | | 1 | 1 | Top end bearing complete with liners, bolts and nuts. |
| 30 | Piston Rings | 1 set | 1 set | Rings. |
| | TURBINES DRIVING ESSENTIAL AUXILIARIES | Spare gear to be the same as for main steam turbines in so far as applicable. | | |
| | AUXILIARY AIR COMPRESSOR | | | |
| 31 | Piston Rings | 1 set | 1 set | Rings, of each size used, for one piston. |
| 32 | Valves | ½ set | ½ set | Suction and delivery valves, complete, of each size used. |
| | ELECTRICAL EQUIPMENT | For items of spare gear to be carried *see* M 20. | | |
| | REFRIGERATING INSTALLATIONS IN SHIPS | For items of spare gear to be carried *see* N 6. | | |
| | **BOILERS** | | | |
| | MAIN AND AUXILIARY BOILERS | | | |
| 33 | Tube Stoppers or Plugs | 20 | 10 | Tube stoppers or plugs, of each size used, for boiler, superheater and economiser tubes. |
| 34 | Fire Bars | 1 set | ½ set | Fire bars for one boiler, where coal fired. |
| 35 | Oil Fuel Burners | 1 set | 1 set | Oil fuel burners complete, for one boiler. |
| 36 | Gauge Glasses | 2 sets per boiler | 2 sets per boiler | Gauge glasses of round type. |
| | | 1 set for every two boilers | 1 set for every two boilers | Gauge glasses of flat type. |
| | DONKEY BOILERS | | | |
| 37 | Tube Stoppers or Plugs | 6 | 6 | Tube stoppers or plugs, complete. |
| 38 | Oil Fuel Burners | 1 set | 1 set | Oil fuel burners, complete, for one boiler. |

*14th June, 1962*

# Chapter M

# ELECTRICAL EQUIPMENT AND ELECTRIC PROPELLING MACHINERY

## Section 1

### GENERAL REQUIREMENTS

**101** (*a*) The requirements of this Chapter apply to passenger ships and cargo ships except where otherwise stated. While these requirements are considered to meet those of the 1960 Safety of Life at Sea Convention, attention should be given to any relevant statutory regulations of the National Authority of the country in which the ship is to be registered.

(*b*) In passenger ships services essential for safety are to be maintained under emergency conditions and the safety of ship and personnel from electrical hazards is to be assured.

(*c*) This Chapter states requirements for those features of the electrical installation which are considered essential for the safety of the ship. The design and installation of other equipment is to be such that there is no risk of fire due to its failure. It must, as a minimum, comply with a national or international standard.

(*d*) The Committee will be prepared to give consideration to special cases or to arrangements which are equivalent to the Rules. Consideration will also be given to the electrical arrangements of small ships and ships to be assigned class notations for restricted or special services.

(*e*) Electrical installations for propulsion and auxiliary services are to be constructed and installed in accordance with the relevant sections of this Chapter and are to be inspected and tested by the Surveyors.

**Plans**

**102** The following plans and particulars are to be submitted in triplicate, for consideration :—

Propulsion Equipment

Plans of generators, motors and seatings together with diagrams of control gear, cables and circuits, and particulars of voltage, current, power and speed with a key diagram and explanation of the system in relation to the requirements of M 17.

Electric Slip Couplings

Plans showing the scantlings and construction of the couplings together with diagrams of electrical components, switchgear and control gear.

Electrical Equipment (other than propulsion equipment)

The arrangement plan and circuit diagram of the switchboard(s). Diagrams of the wiring system including cable sizes, type of insulation, normal working current in the circuits and the capacity, type and make of protective devices. Calculations of short circuit currents at main busbars, sub-switchboard busbars and the secondary side of transformers are to be submitted. (*See* M 611.)

Welding on Shafts

Where welding is to be applied to shafts of machines for essential services for securing armature arms or spiders, plans showing the construction are to be submitted for consideration.

Prime Movers

*See* G 104.

Tankers (compartments in between deck spaces)

*See* M 1605.

Centralised, Bridge or Automatic Controls

*See* G 111.

**Additions or Alterations**

**103** An addition, temporary or permanent, is not to be made to the approved load of an existing installation until it has been ascertained that the current-carrying capacity and the condition of the existing accessories, conductors and switchgear are adequate for the increased load. (*See* C 108.)

Plans are to be submitted for approval and the alterations or additions are to be carried out under the inspection and to the satisfaction of the Surveyors.

### Application

**104** Except where a specific statement is made to the contrary all requirements of this Chapter are applicable to both alternating current and direct current installations.

**105** D.C. equipment is to operate satisfactorily under voltage fluctuations of plus 6 per cent and minus 10 per cent.

A.C. equipment is to operate satisfactorily under voltage fluctuations of plus 6 per cent and minus 10 per cent at rated frequency and under frequency fluctuations of plus or minus 2·5 per cent at rated voltage.

Contactors and similar equipment are not to drop out at or above 85 per cent rated voltage.

### Ambient Temperatures

**106** The following cooling air and cooling water temperatures are applicable in ships classed for:—

(*a*) Unrestricted Service

(i) Primary cooling water supply 30° C. (86° F.)

(ii) Cooling air temperature 45° C. (113° F.)

(*b*) Restricted Service (*See* B 109 and B 110)

Vessels intended solely for use in Northern or Southern waters outside the tropical belt.

(i) Primary cooling water supply 25° C. (77° F.)

(ii) Cooling air temperature 40° C. (104° F.)

### Location and Construction

**107** Electrical equipment is to be accessibly placed clear of inflammable material in well ventilated, adequately lighted spaces in which inflammable gases cannot accumulate and where it is not exposed to risk of mechanical injury or damage from water, steam or oil. Where necessarily exposed to such risks the equipment is to be suitably constructed or enclosed. Live parts are to be guarded where necessary.

Insulating materials and insulated windings are to be resistant to tracking, moisture, sea air and oil vapour unless special precautions are taken to protect them.

Equipment is not to remain alive through the control circuits and/or pilot lamps when switched off by the control switch. This does not apply to synchronizing switches and/or plugs.

The operation of all electrical equipment and the lubricating arrangements are to be efficient under such conditions of vibration and shock as arise in normal practice, and with the ship inclined from the normal at any angle up to 15 degrees transversely, when pitching 10 degrees longitudinally and when rolling up to 22·5 degrees from the vertical.

All nuts and screws used in connection with current carrying parts and working parts are to be effectively locked.

Conductors and equipment are to be placed at such a distance from the magnetic compasses or are to be so disposed that the interfering magnetic field is negligible even when circuits are switched on and off.

Where electric power is used for propulsion, the equipment is to be arranged so that it will operate satisfactorily in the event of partial flooding by bilge water above the tank top up to floor plate level. (*See* E 223 and E 224.)

### Earthing

**108** (*a*) Non-current-carrying metal parts of electrical equipment are to be effectively earthed. Where earthing connections are necessary they are to be of copper or other approved material and are to be protected against damage and, where necessary, electrolytic action. In general they are to be equal to the cross section of the current-carrying conductor up to 0·0225 sq. in (16 sq. mm.). Above this figure they are to be equal to at least half the cross section of the current-carrying conductor with a minimum of 0·0225 sq. in. (16 sq. mm.).

(*b*) Portable Equipment—Metal frames of all portable electric lamps, tools and similar apparatus supplied as ship's equipment and rated in excess of 55 V a.c. or 250 V d.c. are to be earthed through a suitable conductor unless equivalent safety provisions are made such as by double insulation or by an isolating transformer.

### Flameproof and Intrinsically Safe Equipment

**109** Where risk of explosion might otherwise arise, equipment is to be of flameproof or intrinsically safe type.

Where equipment is required to be of flameproof or intrinsically safe type and equipment of suitable type is obtainable which has been type tested and approved by a competent independent Testing Authority, it will be sufficient to furnish a copy of the relevant certificate, provided that there is no departure from the design so tested and approved.

Where certified flameproof equipment is not obtainable, details of the equipment are to be submitted.

NOTE :—

(i) A flameproof enclosure is one which will withstand without injury any explosion of the prescribed flammable gas that may occur within it under practical conditions of operation, and will prevent the transmission of flame such as will ignite the flammable gas in the surrounding atmosphere.

(ii) Intrinsically safe apparatus is to be so constructed that when installed and operated under the conditions specified by the Certifying Authority, any electrical sparking that may occur in normal working, either in the apparatus or in its associated circuit, is incapable of causing an ignition of the prescribed flammable gas or vapour.

### Creepage and Clearance

**110** The distances between live parts and between live parts and earthed metal whether across surfaces or in air shall be adequate for the working voltage having regard to the nature of the insulating material and the transient over-voltages developed by switch and fault conditions.

For bare busbars the following minimum clearance distances shall be observed.

| Voltage between phases or poles | Minimum clearance to earth | | | | Minimum clearance between phases or poles | | | |
|---|---|---|---|---|---|---|---|---|
| | In air | | In oil | | In air | | In oil | |
| | in. | mm. | in. | mm. | in. | mm. | in. | mm. |
| 660 or less | 0·625 | 16 | — | — | 0·75 | 19 | — | — |
| 2200 | 1·5 | 38 | — | — | 1·5 | 38 | — | — |
| 3300 | 2 | 51 | 0·5 | 13 | 2 | 51 | 0·75 | 19 |
| 6600 | 2·5 | 63 | 0·75 | 19 | 3·5 | 89 | 1·0 | 25 |

Where necessary these figures are to be increased to allow for the electro-magnetic forces involved.

### Emergency Source of Power

**111** An emergency source of power, capable of functioning when the ship is inclined 22·5° and/or when the trim of the ship is 10°, is to be installed in accordance with the following :—

Where emergency generating sets are fitted they are to be capable of being started readily when cold.

If hand starting is demonstrated to be practicable, alternative means of starting are not required. Where hand starting is not practicable other means are to be provided and, in general, should provide for not less than 12 starts in a period of 30 minutes without recourse to sources of power within the machinery space.

I PASSENGER SHIPS

(*a*) A self-contained emergency source of electric power is to be installed above the bulkhead deck and outside the machinery casings. Its location in relation to the main source or sources of electric power is to be such as to ensure that a fire or other casualty to the machinery spaces (i.e. spaces containing the main and auxiliary propelling machinery, boilers serving the needs of propulsion and all permanent coal bunkers) will not interfere with the supply or distribution of emergency power. It is not be forward of the collision bulkhead.

(*b*) The power available is to be sufficient to supply all services necessary for the safety of passengers and crew in an emergency, due regard being paid to such services as may have to be operated simultaneously. Special consideration is to be given to emergency lighting at every boat station on deck and overSides, in all alleyways, stairways and exits, in the machinery spaces and in the control stations (i.e. spaces in which radio, main navigating or central fire recording equipment or the emergency generator is located), to the sprinkler pumps, to navigation lights and to the daylight signalling lamp, if operated from the main source of power. The power is to be adequate for a period of 36 hours, except that, in ships engaged regularly on voyages of short duration a lesser supply will be specially considered.

(*c*) The emergency source of power is to be either :—

(i) A generator driven by a suitable prime mover with an independent fuel supply and with satisfactory starting arrangements; the fuel used is to have a flash point of not less than 43° C. (110° F.); or

(ii) An accumulator (storage) battery capable of carrying the emergency load without recharging or excessive voltage drop.

(*d*) (i) Where the emergency source of power is a generator a temporary source of emergency power is to be installed. This is to be an accumulator battery of sufficient capacity :—

(*a*) To supply emergency lighting continuously for 30 minutes;

(*b*) To close the watertight doors (if electrically operated) but not necessarily to close them simultaneously;

(*c*) To operate the indicators (if electrically operated) which show whether power operated watertight doors are open or closed; and

(*d*) To operate the sound signals (if electrically operated) which give warning that power operated watertight doors are about to close.

Arrangements are to be such that the temporary source of emergency power will come into operation automatically in the event of failure of the main electrical supply.

(ii) Where the emergency source of power is an accumulator battery arrangements are to be such that emergency lighting will automatically come into operation on failure of the main lighting supply.

(*e*) An indicator is to be mounted in the machinery space, preferably on the main switchboard, to indicate when any accumulator battery fitted in accordance with this Rule is being discharged.

(*f*) (i) The emergency switchboard is to be installed as near as is practicable to the emergency source of power.

(ii) Where the emergency source of power is a generator, the emergency switchboard is to be located in the same space as the emergency source of power, unless the operation of the emergency switchboard would thereby be impaired.

(iii) No accumulator battery fitted in accordance with this Rule is to be installed in the same space as the emergency switchboard.

(iv) The emergency switchboard may be supplied from the main switchboard during normal operation.

II CARGO SHIPS

(*a*) A self-contained emergency source of power is to be fitted. This may be either :—

(i) An accumulator (storage) battery capable of carrying the emergency load without recharging or excessive voltage drop; or

(ii) A generator driven by a suitable prime mover with an independent fuel supply and with satisfactory starting arrangements; the fuel used is to have a flash point not less than 43° C. (110° F.).

(*b*) Cargo Ships of 5000T gross tonnage and above

(i) The emergency source of power is to be located above the uppermost continuous deck and outside the machinery casings.

(ii) The power available is to be sufficient to supply all services necessary for the safety of all on board in an emergency.

Special consideration is to be given to :—

(*a*) Emergency lighting at every boat station on deck and oversides, in all alleyways, stairways and exits, in the main machinery space and the main generating set space, on the navigating bridge and in the chartroom.

(*b*) The general alarm.

(*c*) Navigation lights if solely electric and the daylight signalling lamp if operated by the main source of power.

(iii) The power is to be adequate for at least six hours operation.

(*c*) Cargo Ships of less than 5000T gross tonnage

The emergency source of power is to be capable of supplying the illumination at launching stations and stowage positions of survival craft in addition to the emergency lighting.

The power available is to be adequate for at least three hours operation.

## Section 2

### SYSTEMS OF SUPPLY

**201** The following systems of distribution may be used :—

(*a*) Parallel systems with constant pressure

Direct Current
Two wire
Three wire with mid-wire earthed.

Alternating Current
Single-phase—two wire
Three phase—
Three wire
Four wire with neutral earthed but without hull return.

Systems employing single wire with hull return may be submitted for special consideration.

(*b*) Series systems with constant current (direct current only).

202 For parallel systems with constant pressure, system voltages for both alternating current and direct current shall not exceed

500 V for generation; power; cooking and heating equipment permanently connected to fixed wiring.

250 V for lighting, heaters in cabins and public rooms and other applications not mentioned above.

203 In very large alternating current installations generation and limited distribution at higher voltages (e.g. 3·3 kV) may be submitted for special consideration.

## Section 3

### DIVERSITY FACTOR

301 Circuits supplying two or more final subcircuits are to be rated in accordance with the total connected load subject, where justified, to the application of a diversity factor. Where spare ways are provided on a section or distribution board an allowance for future increase of load is to be added to the total connected load before application of any diversity factor.

The diversity factor may be applied to the calculation for size of cable and rating of switchgear and fusegear.

#### Winch Circuits

302 For winches the diversity factor is to be calculated and submitted.

## Section 4

### ROTATING MACHINERY

#### Governors

401 Where a turbine driven direct current generator is arranged to run in parallel with other generators a switch is to be fitted in each turbine emergency governor to open the generator circuit breaker when the emergency governor functions. (*See* H 434.)

402 The facilities for adjusting the governor of an alternating current generating set, at normal frequency, are to be sufficiently fine to permit an adjustment of load on the engine within 5 per cent of full load.

#### Number of Generators

403 The number and ratings of ship's service generating sets and converting sets are to be sufficient to ensure the operation of services essential for the propulsion and safety of the ship and preservation of the cargo even when one generating set or converting set is out of service.

#### Rating

404 Ships' service generators, including their exciters and continuously rated motors are to be suitable for continuous duty at their full rated output at maximum cooling air or water temperature for an unlimited period, without the limits of temperature rise in 405 being exceeded. Other generators and motors are to be rated in accordance with the duty which they are to perform and when tested under rated load conditions the temperature rise is not to exceed the values in 405.

#### Temperature Rise

405 Ships for Unrestricted Service

Table 4.1 gives the limits of temperature rise above the cooling air temperature for machines not fitted with water coolers and above the cooling water temperature for machines fitted with coolers, for machines intended to operate in ships classed for unrestricted service.

Ships for Restricted Service (*See* M 106)

For machines intended to operate in ships classed for restricted service as defined in M 106 the temperature rises given may be increased by 5° C. (9° F.) for all machines.

*If it is known that the temperature of the cooling medium exceeds the values given in M 106 the permissible temperature rise is to be reduced by an amount equal to the excess temperature of the cooling medium.*

406 The limits of temperature rise of electric slip couplings are to be in accordance with Table 4.1 except that when a squirrel cage element is used the temperature of this element is not to reach an injurious value. The temperature of the field windings is not to exceed these limits at all speeds of operation. Arrangements for reducing the excitation of self ventilated couplings at low operational speeds are permissible.

407 Alternating current machines of 5000 h.p. or kVA output and above, and propulsion motors having a total axial core length of 1 metre or more

TABLE 4.1

TEMPERATURE RISE IN DEGREES CENTIGRADE

| PART OF MACHINE | | TYPE OF MACHINE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Not Totally Enclosed | | | Totally Enclosed | | | Fitted with Cooler | | |
| | | Class of Insulation | | | | | | | | |
| | | A | E | B | A | E | B | A | E | B |
| A.C. MACHINES | | | | | | | | | | |
| Stator windings rated 1000 V. and above | | | | | | | | | | |
| 1. Outputs below 5000 H.P. or K.V.A. having core length less than 1 metre | R | 50 | 60 | 70 | 50 | 60 | 70 | 70 | 80 | 90 |
| 2. Outputs below 5000 H.P. or K.V.A. having core length of 1 metre or more | ETD | — | 60 | 70 | — | 60 | 70 | — | 80 | 90 |
| 3. Outputs 5000 H.P. or K.V.A. and above irrespective of core length | ETD | — | 60 | 70 | — | 60 | 70 | — | 80 | 90 |
| 4. Stator windings rated below 1000 V. | T | 40 | 50 | 60 | 45 | 55 | 65 | 65 | 75 | 85 |
| 5. Rotor windings (other than 6, 7 and 8) connected to slip rings or commutators | R | 50 | 60 | 70 | 55 | 65 | 75 | 75 | 85 | 95 |
| Salient Pole Field Windings | | | | | | | | | | |
| 6. Single layer with exposed bare surfaces | T or R | 55 | 70 | 80 | 55 | 70 | 80 | 75 | 90 | 100 |
| 7. Other salient pole windings | R | 50 | 60 | 70 | 50 | 65 | 75 | 70 | 85 | 95 |
| | T | 40 | 50 | 60 | 45 | 55 | 65 | 65 | 75 | 85 |
| 8. Non-salient pole field windings (turbine type generators) | R | 55 | 70 | 80 | 55 | 70 | 80 | 75 | 90 | 100 |
| 9. Permanently short-circuited windings (insulated) | T | 55 | 70 | 80 | 55 | 70 | 80 | 75 | 90 | 100 |
| 10. Slip rings | T | 60 | 60 | 60 | 60 | 60 | 60 | 80 | 80 | 80 |
| 11. Commutators | T | 55 | 55 | 55 | 55 | 55 | 55 | 75 | 75 | 75 |
| 12. Iron cores and other parts in contact with insulated windings | T | 45 | 55 | 65 | 45 | 55 | 65 | 65 | 75 | 85 |
| 13. Permanently short-circuited windings, uninsulated | | The temperature rise shall in no case reach such a value that there is risk of injury to any insulating material on adjacent parts | | | | | | | | |
| 14. Iron cores and other parts not in contact with insulated windings | | | | | | | | | | |
| D.C. MACHINES | | | | | | | | | | |
| 15. Armature windings | T | 40 | 50 | 60 | 45 | 55 | 65 | 65 | 75 | 85 |
| | R | 50 | 60 | 70 | 55 | 65 | 75 | 75 | 85 | 95 |
| FIELD WINDINGS | | | | | | | | | | |
| 16. Single layer with exposed bare surfaces | T | 55 | 70 | 80 | 55 | 70 | 80 | 75 | 90 | 100 |
| | R | 65 | 80 | 90 | 65 | 80 | 90 | 85 | 100 | 110 |
| 17. Series and commutating pole windings of more than one layer All compensating windings | T | 50 | 65 | 75 | 50 | 65 | 75 | 70 | 85 | 95 |
| | R | 60 | 75 | 85 | 60 | 75 | 85 | 80 | 95 | 105 |
| 18. Shunt windings and all field windings other than 16 and 17 | T | 40 | 50 | 60 | 45 | 55 | 65 | 65 | 75 | 85 |
| | R | 50 | 60 | 70 | 50 | 60 | 70 | 70 | 80 | 90 |
| 19. Commutators | As item 11 | | | | | | | | | |
| 20. Slip rings | As item 10 | | | | | | | | | |
| 21. Iron cores and other parts in contact with insulated windings | As item 12 | | | | | | | | | |
| 22. Iron cores and other parts not in contact with insulated windings | As item 13 | | | | | | | | | |

R = measurement by resistance T = measurement by thermometer ETD = measurement by embedded temperature detector.

NOTE.—(i) Proposals to employ Class F or Class H insulation will be specially considered.
(ii) Classes of insulation are to be in accordance with I.E.C. Publication No. 85 (1957)—Recommendations for the Classification of Material for the Insulation of Electrical Machinery and Apparatus in relation to their thermal stability in service.

are to have at least three embedded temperature detectors. With multi core machines the total length is to be taken as the sum of the individual core lengths.

### Overloads

**408** Machines are to withstand, on test, without injury the following momentary overloads.

GENERATORS : An excess current of 50 per cent for 15 sec. after attaining the temperature rise corresponding to rated load, the terminal voltage being maintained as near the rated value as possible.

MOTORS : At rated speed or, in the case of a range of speeds, at the highest and lowest speeds, under gradual increase of torque the appropriate excess torque given below. Synchronous motors and synchronous induction motors are required to withstand the excess torque without falling out of synchronism and without adjustment of the excitation circuit preset at the value corresponding to rated load.

| | |
|---|---|
| D.C. motors ... ... ... ... | 50% for 15 sec. |
| Polyphase A.C. synchronous motors | 50% for 15 sec. |
| Polyphase A.C. synchronous induction motors ... ... ... ... | 35% for 15 sec. |
| Polyphase A.C. induction motors ... | 60% for 15 sec. |

The overload tests for propulsion machines will be specially considered for each installation.

### Short Circuit

**409** The stator and rotor windings of alternating current propulsion generators are to be capable of withstanding a momentary short circuit at the terminals of the machine applied when generating full rated voltage. Ship's service generators are to be capable of withstanding the mechanical and thermal effects of fault current for the duration of any time delay which may be fitted in a tripping device for discrimination purposes.

### Insulation

**410** The windings of machines for essential services are to be insulated from their frames or cores with mica or micanite or material, other than Class A, not less effective than micanite and having similar non-hygroscopic and anti-tracking properties.

### Shaft Currents

**411** Means are to be taken to prevent the ill effects of flow of currents circulating between the shaft and bearings.

### Welding on Shafts

**412** Where welding is applied to shafts of machines for securing armature arms or spiders, stress relieving is to be carried out after welding.

### Brushgear

**413** The final running position of brushgear is to be clearly and permanently marked.

Direct current motors and generators are to work with fixed brush setting from no load to the momentary overload specified without injurious sparking.

Alternating current commutator motors are to work over the specified range of load and speed without injurious sparking.

### Direct Current Service Generators

**414** Direct current generators other than those referred to in 415 are to be either

(i) compound wound

or (ii) shunt wound and operated in conjunction with an automatic voltage regulator.

**415** Direct current generators used for charging batteries without series-regulating resistors are to be either

(i) shunt wound

or (ii) compound wound with switches arranged so that the series winding can be switched out of service.

**416** Means are to be provided at the switchboard to enable the voltage of each generator to be adjusted separately.

For each direct current generator, coupled to its prime mover, at any temperature within the working range the means provided is to be capable of adjusting the voltage at any load between no load and full load to within :—

0·5 per cent of rated voltage for generators of rating exceeding 100 kW.

1·0 per cent of rated voltage for generators of rating not exceeding 100 kW.

**417** The inherent regulation of ship's service generators is to be such that the following conditions are satisfied :—

For shunt or stabilised shunt wound generators when the voltage has been set at full load, the steady voltage at no load shall not exceed 115 per cent of the

full load value, and the voltage obtained at any intermediate value of load shall not exceed the no load value.

For compound wound generators with the generator at full load operating temperature and starting at 20 per cent load with voltage within 1 per cent of rated voltage, then at full load the voltage is to be within 2·5 per cent of rated voltage. The average of the ascending and descending load/voltage curves between 20 per cent load and full load is not to vary more than 4 per cent from rated voltage.

**418** Generators are to be capable of delivering continuously the full load current and normal rated voltage at the terminals when running at full load engine speed at all ambient temperatures up to the specified maximum.

**419** Generators required to run in parallel are to be stable from no load up to the total combined load of the group and load sharing is to be satisfactory.

**420** The series winding of each two-wire generator is to be connected to the negative terminal.

**421** Equaliser connections are to have a cross sectional area appropriate to the system but in no case less than 50 per cent of that of the negative connection from the generator to the switchboard.

### Alternating Current Service Generators

**422** Each alternating-current service generator, unless of the self-regulated type, is to be operated in conjunction with a separate automatic voltage regulator.

**423** The voltage regulation of any alternating current generator with its AVR is to be such that at all loads from zero to full load the rated voltage at rated power factor is maintained under steady conditions within $\pm 2{\cdot}5$ per cent.

**424** In alternating current systems with one generator set out of action, the remaining set(s) are to have sufficient reserve capacity to permit the starting of the largest motor in the ship without causing any motor to stall or any other device to fail due to excessive voltage drop on the system.

**425** Alternating current generators required to run in parallel are to be stable from 20 per cent full load (kW) up to the total combined full load (kW) of the group and load sharing is to be satisfactory.

**426** When generators are operated in parallel the kVA loads of the individual generating sets are not to differ from their proportionate share of the total kVA load by more than 5 per cent of the rated kVA output of the largest machine when operating at 0·8 power factor.

### Inspection and Testing

**427** On machines for essential services tests are to be carried out and a certificate furnished by the manufacturer. The tests are to include temperature rise, momentary overload, high voltage, and commutation. The insulation resistance and the temperature at which it was measured shall be recorded. Shaft materials are to comply with Chapter P.

Generators of 100 kW or over and motors of 100 h.p. and over intended for essential services are to be inspected by the Surveyors during manufacture and testing. (A list of essential services is given in M 2002.) Shaft materials are to be tested in accordance with P 6.

**428** In the case of duplicate machines up to 50 kW, kVA or b.h.p. per 1000 r.p.m. type tests of temperature rise, excess current and torque and commutation taken on a machine identical in rating and in all other essential details may be accepted in conjunction with abbreviated tests on each machine. This is not to apply to propulsion machines. For the abbreviated tests, each machine is to be run and is to be found electrically and mechanically sound and is to have a high voltage test and insulation resistance recorded.

### High Voltage Test

**429** A high voltage test of 1000 V plus 2 × rated voltage with a minimum of 2000 V is to be applied to new machines preferably at the conclusion of the temperature rise test. The test is to be applied between the windings and the frame with the core connected to the frame and to any windings (or sections of windings) not under test. Where both ends of each phase are brought out to accessible separate terminals each phase is to be tested separately. The test is to be made with alternating voltage at any convenient frequency between 25 and 100 cycles per second of approximately sine wave form. The test is to be commenced at a voltage of about one-third the test voltage and is to be increased to full value as rapidly as is consistent with its value being indicated by the measuring instrument. The full test voltage is then to be maintained for one minute, and then reduced to one-third full value before switching off.

When it is desired to make additional high voltage tests on a machine which has already passed its tests the voltage of such additional tests is to be 75 per cent of the figure given above.

### Motors for Refrigerated Cargo Services

**430** Motors intended for coupling to fans for the circulation of air in refrigerated cargo spaces are to be inspected by the Surveyors during manufacture and testing.

Plans showing the construction of the motors are to be submitted for consideration.

Fan motors fitted in the air stream are to be totally enclosed or otherwise suitably enclosed to withstand the effects of excessive moisture where they are fitted between the two sections of a cooler or where the air from the cooler passes over the motor.

The Surveyors will witness a type test on the first motor of each size and type and works test certificates are to be supplied for the remainder. This type test may also be accepted for repeat orders of motors identical in all essential respects provided cross references are given in the works test certificates. Type tests need not be carried out for motors of the same frame size as one previously tested for higher output.

Where motors are mounted in the air stream but are to be tested in still air conditions generally two conditions arise :—

(i) The motor may be open at one end or both ends when tested but totally enclosed when mounted in the air stream. In such cases a type test should be carried out under working conditions, i.e., in the trunking with the fan and fairings in place or alternatively, calculations furnished to show that the Rules for temperature rise are complied with.

(ii) The motor may be totally enclosed but with streamlined fairings. These may be accepted if, when tested in still air, the temperature rises are within the requirements of the Rules for totally enclosed motors. If they are outside these requirements the procedure in (i) is to be followed.

### Electric Slip Couplings

**431** Slip couplings are to be inspected by the Surveyors during manufacture and testing. Unless otherwise approved, every coupling is to be tested at the makers' works, the tests to include :—

Temperature rise test

High voltage test

Insulation resistance is to be recorded, together with the temperature at which it was measured.

## Section 5

## DISTRIBUTION

### Final Sub-Circuits

**501** A final sub-circuit of rating exceeding 15A is not to supply more than one point. The number of lighting points supplied by a final sub-circuit of rating 15A or less is not to exceed :—

| | | | |
|---|---|---|---|
| for | 24 — 55 V | circuits | 10 |
| „ | 110 — 127 V | „ | 14 |
| „ | 220 — 250 V | „ | 18 |

except that in final sub-circuits for cornice lighting, panel lighting and electric signs where lampholders are closely grouped the number of points supplied is unrestricted provided the maximum operating current in the sub-circuit does not exceed 10A.

**502** A separate final sub-circuit is to be provided for every motor required for essential services.

**503** Lighting circuits are to be supplied by final sub-circuits separate from those for heating and power. (This does not apply to cabin fans and wardrobe heaters.)

**504** Lighting of cargo spaces and coal bunkers is to be controlled by multi-pole linked switches situated outside these spaces. Provision is to be made for the complete isolation of these circuits and locking in the off position of the means of control.

### Navigation Lights

**505** Navigation lights are to be connected separately to a distribution board reserved for this purpose only, and connected directly or through transformers to the main or emergency switchboard. The distribution board is to be accessible to the officer of the watch.

Each navigation light is to be controlled and protected in each insulated pole by a switch and fuse or circuit breaker mounted on the distribution board.

Where the navigation panel is situated in the midships house, the midships sub-switchboard is regarded as an extension of the main switchboard providing it is supplied from the main switchboard by two cables each capable of carrying full load.

Each navigation light is to be provided with an automatic indicator giving aural and/or visual indication of failure of the light. If an aural device alone is fitted it is to be connected to a primary or secondary battery. If a visual signal is used connected in series with the navigation light means are to be provided to prevent extinction of the navigation light due to failure of the signal. The requirements of this paragraph do not apply to tugs, trawlers, fishing and similar small vessels.

Provision is to be made on the bridge for such navigation lights to be transferred to an alternative circuit.

Any statutory requirements of the country of registration are to be complied with and may be accepted as an alternative to the above.

### Steering Gear

**506** (*a*) Only short circuit protection and overload alarm are to be provided in steering gear circuits.

(*b*) Indicators for running indication of steering gear motors are to be installed.

The exact position of the rudder, if power operated, is to be indicated at the principal steering station.

(*c*) In all passenger ships and in cargo ships of 5000T gross tonnage and upwards electric and electro-hydraulic steering gear is to be served by two circuits fed from the main switchboard. One of the circuits may pass through the emergency switchboard. Each circuit is to have adequate capacity for supplying all the motors which are normally connected to it and which operate simultaneously.

If transfer arrangements are fitted in the steering gear room to permit either circuit to supply any motor or combination of motors, the capacity of each circuit is to be adequate for the most severe load conditions.

The circuits are to be separated throughout their length as widely as is practicable.

(*d*) In cargo ships of less than 5000T gross tonnage where electric power is the sole source of power for both main and auxiliary steering gear the supply arrangements are to comply with (*c*) above.

If the auxiliary steering gear is powered by a motor primarily intended for other services alternative protective arrangements to that required by sub-para. (*a*) will be specially considered.

### Fire Extinguishing Systems

**507** (*a*) Where electrically driven emergency fire pumps are installed in accordance with F 403 and F 505, the supply to such pumps is not to pass through the main machinery spaces.

(*b*) Any fire alarm system is to operate both audible and visual signals at the fire detection control station(s). Detection systems for cargo spaces need not have audible alarms.

In addition, the following apply to passenger ships :—

(*c*) Electrical equipment used in operating fire detecting equipment is to have two sources of electrical power, one of which is to be the emergency source. (*See* M 111.)

(*d*) Where automatic sprinkler systems are fitted and electrical power is used for the operation of sea water pumps, air compressors and alarms fitted in conjunction with such systems at least two sources of power are to be arranged. The sources of power are to be a main generator and the emergency source of power. (*See* M 111.) One supply is to be taken from the main switchboard by separate feeders reserved solely for this purpose. Such feeders are to be run to a change-over switch situated near the sprinkler unit and the switch is to be normally closed to the feeder from the emergency switchboard. The change-over switch is to be clearly labelled and no other switch other than those at the switchboard(s) is permitted in these feeders.

In passenger ships with aluminium superstructures where feeders from the emergency generator to the sprinkler unit pass through any space constituting a fire risk the cables are to be of fireproof type.

### Heating and Cooking

**508** Each item of heating or cooking equipment is to be controlled as a complete unit by a multi-pole linked switch mounted in the vicinity of the equipment. In the case of cabin heaters a single pole switch will be acceptable.

### Shore Supply

**509** (*a*) Where arrangements are made for the supply of electricity from a source on shore or elsewhere a suitable connection box is to be installed in a

position in the ship suitable for the convenient reception of flexible cables from the external source and containing a circuit breaker or isolating switch and fuses and terminals of ample size and suitable shape to facilitate a satisfactory connection. Suitable cables, permanently fixed, are to be provided, connecting the terminals to a linked switch and/or a circuit breaker at the main switchboard.

(*b*) For three-phase shore supplies with earthed neutral an earth terminal is to be provided for connecting the hull to the shore earth.

(*c*) The shore connection is to be provided with an indicator at the main switchboard in order to show when the cable is energised.

(*d*) Means are to be provided for checking the polarity (for direct current) or the phase sequence (for three-phase alternating current) of the incoming supply in relation to the ship's system.

(*e*) At the connection box a notice is to be provided giving full information on the system of supply and the normal voltage (and frequency if alternating current) of the ship's system and the procedure for carrying out the connection.

(*f*) Alternative arrangements may be submitted for consideration.

### Submersible Bilge Pumps

**510** Motors of permanently installed submersible bilge pumps are to be connected to the emergency switchboard (if fitted).

Cables and their connections to such pumps are to be capable of operating under a head of water equal to their distance below the bulkhead deck. The cables are to be suitable for operation in permanently wet situations, and installed in continuous lengths from above the bulkhead deck to the motor terminals.

Under all circumstances it is to be possible to start the motor of a permanently installed submersible bilge pump from a position above the bulkhead deck.

## Section 6

## SWITCHBOARDS, SWITCHGEAR AND PROTECTIVE EQUIPMENT

### Switchboards

**601** (*a*) An unobstructed space is to be left in front of switchboards. Pipes should, as far as possible, not be installed directly above or in front of or behind switchboards. If such placing is unavoidable suitable protection is to be provided in these positions. (*See* E 275.)

(*b*) Where necessary the space at the rear of switchboards is to be ample to permit maintenance and in general not less than 24 in. (0,6 m.) except that this may be reduced to 18 in. (0,5 m.) in way of stiffeners or frames.

(*c*) For voltages between poles or to earth above 55 V a.c. or 250 V d.c. dead front switchboards are to be used. Where live parts on a switchboard are adjacent to a gangway an insulated handrail is to be provided and non-conducting mats or gratings are to be fitted at front and rear of the switchboard as necessary.

(*d*) Section and distribution boards are to be suitably enclosed unless they are installed in a cupboard or compartment to which only authorised persons have access, in which case the cupboard may serve as the enclosure.

All enclosures are to be constructed of, or lined with, non-flammable and non-hygroscopic material and are to be of robust construction.

(*e*) All measuring instruments and all apparatus controlling circuits are to be clearly and indelibly labelled for identification purposes. An indelible label is to be permanently secured to, or adjacent to, every fuse and every circuit breaker and marked with particulars of the full load current of the generator or cable which the fuse or circuit breaker protects. The labels for rewirable fuses are also to be marked with the appropriate size of fuse element. Where inverse time limit and/or reverse current devices are provided in connection with a circuit breaker, the appropriate settings of these devices are to be stated on the label. Nameplates are to be of flame-retardant material.

(*f*) In a passenger ship where there is only one main generating station the main switchboard is to be located in the same fire zone. Where there is more than one main generating station it is permissible to have only one main switchboard.

### Busbars

**602** Busbars and their connections are to be of copper, all connections being made so as to inhibit corrosion. Busbars and their supports are to be so designed as to withstand the mechanical stresses which will arise during short circuits. The maximum permissible temperature rise for bare conductors is 45° C. (81° F.).

**Equaliser Connections**

**603** The current rating of equaliser connections and equaliser switches is to be not less than half the rated full load current of the generator. The current rating of equaliser busbars is to be not less than half the rated full load current of the largest generator in the group.

**Instruments for Direct Current Generators**

**604** (*a*) For generators not operated in parallel at least one voltmeter and one ammeter are to be provided for each generator.

(*b*) For parallel operation one ammeter is to be provided for each generator, and two voltmeters. One voltmeter is to be connected to the busbars and the other is to be capable of measuring the voltage of any generator.

(*c*) For compound wound generators fitted with equaliser connections the ammeter is to be connected to the pole opposite to that connected to the series winding of the generator.

(*d*) For three-wire generators the ammeter is to be located between the equaliser connection and the generator.

(*e*) For three-wire systems supplied by a three-wire generator or by a balancing booster an ammeter is to be connected to each outer pole of each balancing generator and a voltmeter between each pole of the busbars and the middle wire.

**Instruments for Alternating Current Generators**

**605** (*a*) For alternating current generators not operated in parallel each generator is to be provided with at least one voltmeter, one frequency meter and one ammeter with an ammeter switch to enable the current in each phase to be read or an ammeter in each phase and for generators above 50 kVA a wattmeter.

(*b*) For alternating current generators operated in parallel each generator is to be provided with a wattmeter, and an ammeter in each phase conductor or an ammeter with a selector switch to permit the measuring of current in each phase.

For paralleling purposes two voltmeters, two frequency meters and a synchronising device comprising either a synchroscope and lamps, or an equivalent arrangement, are to be provided. One voltmeter and one frequency meter are to be connected to the busbars, the other voltmeter and frequency meter are to be switched to enable the voltage and frequency of any generator to be measured.

**Instrument Scales**

**606** (*a*) The upper limit of the scale of every voltmeter is to be approximately 120 per cent of the normal voltage of the circuit and the normal voltage is to be clearly indicated.

(*b*) The upper limit of the scale of every ammeter is to be approximately 130 per cent of the normal rating of the circuit in which it is installed. Normal full load is to be clearly indicated.

(*c*) Ammeters for use with direct current generators and kW meters for use with alternating current generators which may be operated in parallel are to be capable of indicating 15 per cent reverse current or power respectively.

**Instrument Transformers**

**607** The secondary windings of instrument transformers are to be earthed.

**Earth Indication**

**608** Every insulated distribution system is to be provided with lamps or other means to indicate the state of insulation from earth.

**Protection**

**609** Installations are to be protected against accidental overcurrents including short-circuit. The protective devices are to provide complete and co-ordinated protection to ensure :—

(i) Continuity of service under fault conditions through discriminative action of the protective devices.

(ii) Elimination of the fault so as to reduce damage to the system and hazard of fire.

**Protection against Overload**

**610** Circuit-breakers and automatic switches provided for overload protection are to have tripping characteristics appropriate to the system. Fuses above 320A are not to be used for overload protection, but may be used for short-circuit protection.

Over-current releases of circuit-breakers for generators and for circuits with preference tripping are to be adjustable.

NOTE.—Overload is considered to be an over-current in a circuit in which the insulation is still effective. Short circuit is considered to be an over-current in a circuit in which the insulation is defective.

**Protection against Short Circuit**

**611** Protection against short-circuit currents is to be provided by circuit-breakers or fuses.

The breaking capacity of every protective device is to be not less than the maximum value of the short-circuit current which can flow at the point of installation at the instant of contact separation.

The making capacity of every circuit-breaker or switch intended to be capable of being closed, if necessary, on short-circuit, is to be not less than the maximum value of the short-circuit current at the point of installation. On alternating current this maximum value corresponds to the peak value allowing for maximum asymmetry.

Every protective device or contactor not intended for short-circuit interruption is to be adequate for the maximum short-circuit current which can occur at the point of installation having regard to the time required for the short-circuit to be removed.

In the absence of precise data the following short-circuit currents at the machine terminals are to be assumed :—

D.C. Systems

Ten times full load current for generators normally connected (including spare).

Six times full load current for motors simultaneously in service.

A.C. Systems

Ten times full load current for generators normally connected (including spare)—symmetrical RMS.

Three times full load current for motors simultaneously in service.

### Combined Circuit-Breakers and Fuses

**612** The use of a circuit-breaker of breaking capacity less than the prospective short-circuit current at the point of installation is permitted provided that it is preceded on the generator side by fuses, or by a circuit-breaker having at least the necessary breaking capacity. The generator breakers are not to be used for this purpose.

Fused circuit-breakers with fuses connected to the load side may be used where operation of the circuit-breaker and fuses is co-ordinated.

The characteristics of the arrangement shall be such that :—

(i) When the short-circuit current is broken the circuit-breaker on the load side shall not be damaged and is to be capable of further service.

(ii) When the circuit-breaker is closed on the short-circuit current the remainder of the installation shall not be damaged. It is, however, admissible that the circuit-breaker on the load side may require servicing after the fault has been cleared.

### Protection of Circuits

**613** Short-circuit protection is to be provided in each live pole of a direct-current system and in each phase of an alternating-current system.

Overload protection is to be provided in :—

Two-wire d.c. or single-phase a.c. system—at least one line or phase.

Three-wire d.c. system—both outer lines.

Insulated three-phase a.c. system—at least two phases.

Earthed three-phase a.c. system—all three phases.

No fuse, non-linked switch or non-linked circuit-breaker is to be inserted in an earthed conductor. Any switch or circuit-breaker fitted is to operate simultaneously in the earthed conductor and the insulated conductors.

These requirements do not preclude the provision (for test purposes) of an isolating link to be used only when the other conductors are isolated.

### Protection of Generators

**614** In addition to over-current protection the following protective gear is to be provided as a minimum :—

(*a*) For generators not arranged to run in parallel : A circuit-breaker arranged to open simultaneously all insulated poles or in the case of generators rated at less than 50 kW a multi-pole-linked switch with a fuse in each insulated pole.

(*b*) For generators arranged to operate in parallel : A circuit-breaker arranged to open simultaneously all insulated poles. This circuit-breaker is to be provided with :—

(i) For direct-current generators, instantaneous reverse-current protection operating at not more than 15 per cent rated current.

(ii) For alternating-current generators a reverse-power protection, with time delay, selected and set within the limits of 2 per cent to 15 per cent of full load to a value fixed in accordance with the characteristics of the prime mover.

The reverse-current protection is to be adequate to deal with the reverse-current conditions emanating from the ship's network, e.g., cargo winches. The reverse-power protection specified for alternating-current generators may be replaced by other devices ensuring adequate protection of the prime movers.

(*c*) In addition the following is to be provided for direct-current generators arranged to operate in parallel.

(i) Where an equaliser connection is in use the reverse-current protection is to be provided in the pole opposite to that in which the series winding is connected.

(ii) For compound generators an equaliser switch for each generator so interlocked that it closes before and opens after the main contacts of the circuit-breaker with which it is associated, or a three-pole circuit-breaker with all poles operating simultaneously.

(iii) In three-wire systems a switch in the connection to the middle wire so interlocked with the generator switch or circuit-breaker connected to the outers as to operate simultaneously with them.

**Essential Services**

**615** Where generators are operated in parallel and essential machinery is electrically driven arrangements are to be made to disconnect automatically the excess non-essential load when the generators are overloaded.

If required this load shedding may be carried out in one or more stages.

Circuits for cargo refrigeration machinery are to be included in the last group to be disconnected.

**Power Transformers**

**616** The primary circuits of power transformers are to be protected against short-circuit by circuit-breakers or fuses.

When transformers are arranged to operate in parallel means of isolation are to be provided on the secondary windings. Switches and circuit-breakers are to be capable of withstanding surge currents.

**Feeder Circuits**

**617** Isolation and protection of each main distribution circuit is to be ensured by a multi-pole circuit breaker or switch and fuses. Protection is to be in accordance with 610, 611 and 613 except that steering gear circuits are to have short-circuit protection only and overload alarm. The protective devices are to allow excess current to pass during the normal accelerating period of motors.

Circuits which supply motors fitted with overload protection may be provided with short-circuit protection only.

Motors of rating exceeding 0·5 kW/h.p. and all motors for essential services are to be protected individually against overload and short-circuit. The short-circuit protection can be provided by the same protective device for the motor and its supply cable. For essential motors which are duplicated the overload protection may be replaced by an overload alarm if desired by the owner.

For motors intended to provide uninterrupted service the protective gear is to have a delay characteristic to enable the motor to start, yet which will operate on overload before the windings reach an unacceptably high temperature. The current which the protective device will allow to pass indefinitely is not to exceed 125 per cent of the rated current.

For motors for intermittent service the current setting and the delay are to be chosen in relation to the load factor of the motor.

Lighting circuits are to be provided with overload and short-circuit protection.

**Meters, Pilot Lamps, Capacitors**

**618** Protection is to be provided for voltmeters, voltage coils of measuring instruments, earth indicating devices and pilot lamps together with their connecting leads.

A pilot lamp installed as an integral part of another item of equipment need not be individually protected, provided it is fitted in the same enclosure. Where a fault in a pilot lamp would jeopardise the supply to essential equipment such lamps are to be individually protected.

Where capacitors for suppression of radio interference are fitted to busbars, generators, or steering-gear, fuses of appropriate size are to be connected in the capacitor circuit.

**Switchgear**

**619** (*a*) Circuit-breakers and switches are to be of the air break type.

(*b*) The limits of temperature rise are to be based on the cooling air temperatures given in Section 1, and when measured by thermometer or thermocouple are not to exceed :—

| | | |
|---|---|---|
| Contacts : Solid copper ... | 40° C. | (72° F.) |
| Silver or similar | 65° C. | (117° F.) |
| Bare conductors and connections | 45° C. | (81° F.) |

| | | |
|---|---|---|
| Coils : Class A insulation ... | 50° C. | (90° F.) |
| Class E insulation ... | 65° C. | (117° F.) |
| Class B insulation ... | 80° C. | (144° F.) |

(*c*) Reports of tests to establish the capacity of circuit-breakers are to be submitted for consideration when required.

(*d*) Each circuit opening device is to be so arranged that when placed in the OFF position it cannot accidentally move so as to close the circuit.

(*e*) Circuit-breakers are to be of the trip free type.

(*f*) The over-current releases of circuit-breakers for generators and the setting of preference tripping relays are to be adjustable.

(*g*) Where reverse-power or reverse-current protection is provided it is to be appropriate to the circumstances of reverse-power between the limits of 2 per cent and 15 per cent of full load that may be expected. (*See* 614(b).)

(*h*) A fall of 50 per cent in the applied voltage shall not render the reverse-current mechanism inoperative although it may alter the amount of reverse-current required to open the breaker.

(*i*) Over-current releases are to be calibrated in amperes, and the settings marked on the circuit-breaker.

(*j*) Handles and operating mechanisms are to be so arranged that the hand of the operator cannot accidentally touch live metal or be injured through an arc arising from the switch or circuit breaker, or the rupturing of a fuse. If switches are enclosed their handles are not to operate through unprotected slots.

### Testing

**620** Before installation, switchboards complete or in sections with all components are to pass the following tests at the manufacturers' works and a certificate furnished. A high voltage test is to be carried out on all switching and control apparatus for systems greater than 60 V with a test voltage of 1000 V plus twice the rated voltage (minimum 2000 V) at any frequency between 25 c/s and 100 c/s for one minute applied between (i) all current-carrying parts connected together and earth and (ii) between current-carrying parts of opposite polarity or phase.

For systems of 60 V or less the test shall be at 500 V for one minute.

Immediately after the high voltage test the insulation resistance between (i) all current-carrying parts connected together and earth and (ii) between current-carrying parts of opposite polarity or phase, shall be not less than 1 megohm when tested with a d.c. voltage of at least 500 V.

Instruments and ancillary apparatus may be disconnected during the high voltage test.

### Fuses

**621** Fuses are to comply with an approved national standard or with the recommendations of the International Electrotechnical Commission and with the following clauses.

The breaking capacity of the fuse is to be not less than the prospective short-circuit current at the point of installation.

Fuses are to be suitable for operating in the ambient temperatures given in M 106 and the temperature rise at the terminals is to be such that the maximum permissible temperature(s) of the connected cable(s) is not exceeded.

**622** Fuse-links and fuse-bases are to be marked with particulars of rated current and rated voltage. Each fuse position is to be permanently and indelibly labelled with the current-carrying capacity of the circuit protected by it and with the appropriate approved size of fuse or replaceable element.

**623** A list of approved fuses will be issued. To secure approval a report, preferably by an independent authority, is to be submitted giving details of test performance, fusing characteristics, temperature and insulation tests and details of the specification to which the fuse had been tested. Outline drawings are to be included but samples should not be submitted unless requested.

## Section 7

### CONTROL GEAR

**701** The limits of temperature rise for control gear are to be based on the cooling air temperatures given in M 106.

The temperature rise, at full rated load, measured by thermometer or thermocouple is not to exceed :—

| | | |
|---|---|---|
| Contacts : Solid copper ... | 60° C. | (108° F.) |
| Silver or similar ... | 75° C. | (135° F.) |
| Bare conductors and connections | 45° C. | (81° F.) |
| Coils : Class A insulation ... | 60° C. | (108° F.) |
| Class E insulation ... | 75° C. | (135° F.) |
| Class B insulation ... | 90° C. | (162° F.) |

Resistors—maximum operating temperatures shall not exceed 410° C. (770° F.).

Other parts whether insulated or not are not to reach a temperature which might harm the parts themselves or materials with which they are in contact.

**702** Control gear, including isolating and reversing switches is to be so arranged that shunt field circuits are not disconnected without an adequate discharge path being provided.

**703** Every electric motor is to be provided with efficient means of starting and stopping so placed as to be easily operated by the person controlling the motor. Every motor above 0·5 kW/h.p. is to be provided with the following control apparatus:—

(*a*) Means to prevent undesired restarting after a stoppage due to low volts or complete loss of volts. This does not apply to motors, the continuous availability of which is essential to the safety of the ship.

(*b*) Efficient means of isolation are to be provided so that all voltage may be cut off from the motor and any associated apparatus including any automatic circuit-breaker.

Where the primary means of isolation (that provided at the switchboard, section board or distribution fuse board) is remote from a motor, one of the following is to be provided:—

(i) An additional means of isolation fitted adjacent to the motor.

or (ii) Provision made for locking the primary means of isolation in the OFF position.

or (iii) Provision made so that the fuses in each line can be readily removed and retained by authorised personnel.

(*c*) Means for automatic disconnection of the supply in the event of excess current due to mechanical overloading of the motor (this does not apply to steering motors). (*See also* M 617.)

(*d*) Where fuses are used to protect polyphase motor circuits, means are to be provided to protect the motor against unacceptable overload in the case of single phasing.

**704** When selecting motor control gear the maximum current of a motor is to be taken as the full load rated current of the motor.

**705** Where a single master-starter system (e.g., a starter used for controlling a number of motors successively) is used the apparatus is to provide under-voltage and over-current protection and means of isolation for each motor not less effective than that required for systems using a separate starter for each motor. Where the starter is of the automatic type, suitable alternative means are to be provided for manual operation. Where the starter is used for motors for essential services the starting portion shall be duplicated and means are to be provided for the transfer of the starting duties in the event of failure of one of the starters.

**706** Means are to be provided for stopping ventilating fans serving machinery and cargo spaces. These means are to be capable of being operated from outside such spaces in case of fire.

Machinery driving forced and induced draught fans, oil fuel transfer pumps, oil fuel unit pump and other similar fuel pumps are to be fitted with remote controls situated outside the space concerned so that they may be stopped in the event of fire arising in the space in which they are located.

In passenger ships carrying more than 36 passengers all power ventilation systems, except cargo and machinery space ventilation, which is to be in accordance with the first sub-paragraph, are to be fitted with master controls so that all fans may be stopped from either of two separate positions which are to be situated as far apart as practicable.

**707** Control gear and resistors are to be tested by the makers with a high voltage applied between the earthed frame and all live parts. The test voltage is to be 1000 V plus twice the rated voltage with a minimum of 2000 V. The voltage is to be alternating at any frequency between 25 and 100 c/s and is to be maintained for one minute without failure.

Immediately after the high voltage test the insulation resistance between (i) all current-carrying parts connected together and earth and (ii) between current-carrying parts of opposite polarity or phase, shall be not less than 1 megohm when tested with a direct current voltage of at least 500 V. Instruments and auxiliary apparatus may be disconnected during the high voltage test.

## Section 8

### CABLES

#### Conductors

**801** High conductivity annealed copper only is to be used. For rubber-insulated cables the copper wire is to be tinned or alloy coated and the surface is to be bright.

Conductor composition and stranding is to be selected so that adequate flexibility of the finished cable is assured. Conductors of nominal cross section 0·003 sq. in. (2,5 sq. mm.) and less need not be stranded. This requirement does not apply to mineral-insulated cables which have solid conductors. Cores of multi-core cables are to be readily identifiable.

### Insulating Materials

**802** The following insulating materials are permitted:—

TABLE 8.1

| Insulating Material | Maximum rated conductor Temp. °C. | Maximum Ambient Temp. °C. |
|---|---|---|
| Natural or synthetic rubber (general purpose) ... ... | 60 | 50 |
| Polyvinyl chloride compound (general purpose) ... ... | 60 | 50 |
| Natural or synthetic rubber (heat resisting) ... ... | 75 | 65 |
| Varnished cambric, Butyl ... | 80 | 70 |
| Asbestos-varnished cambric ... | 85 | 75 |
| Silicone rubber ... ... | 95 | — |
| Mineral... ... ... ... | 95 | — |

NOTE.—Silicone rubber and mineral insulation may be used for higher temperatures when installed where they are not liable to be touched by ship's personnel viz. silicone rubber 150° C. mineral unlimited. Proposals to employ these higher temperatures will be specially considered.

Where a rubber or rubber-like material with maximum conductor temperature greater than 60° C. is used it is to be readily identifiable.

Other insulating materials will be considered.

### Insulation

**803** (*a*) RUBBER—The use of a single layer is permitted only when applied by the extrusion process. With other processes the insulation is to consist of at least two layers of rubber compound equal or different in quality (including polychloroprene compound but not pure rubber). The layers are to be bonded together.

The insulating wall is to be close fitting, but not adherent to the conductor.

(*b*) POLYVINYLCHLORIDE—Polyvinylchloride insulation is to be applied by extrusion in one or more layers, is to be close fitting but not adherent to the conductor.

(*c*) VARNISHED CAMBRIC—Varnished cambric is to consist of a closely woven cloth tape uniformly coated on both sides with an insulating varnish. The average thickness of the finished cloth is to be not less than 5 mils (0,13 mm.) nor more than 13 mils (0,33 mm.).

The insulating wall is to consist of several layers of varnished cambric tape, applied helically and smoothly, with or without overlapping, each tape covering the gap, if any, of the underlying tape.

An insulating and lubricating compound is to be applied between the layers of varnished cloth so as to exclude air and moisture.

If a binder or identification tape is used and is made of insulating material it may be considered as part of the insulating wall.

(*d*) ASBESTOS-VARNISHED CAMBRIC—The insulation of each conductor is to consist of a layer of felted asbestos, impregnated with heat and moisture resisting compound, plus layers of varnished cambric tape plus a layer of impregnated-felted asbestos. In place of felted asbestos, asbestos roving, glass roving, asbestos tape or glass tape may be used.

(*e*) MINERAL INSULATION—Mineral insulation is to consist of a powdered mineral material, e.g., magnesium oxide, highly compressed between conductors and copper sheath. It is to be temperature-stable and non-corrosive to copper.

### Construction

**804** Whatever the insulating material used both the belted and non-belted construction may be used for two, three and more conductor cables.

### Non-belted Cables

**805** For non-belted cables the spaces among the cores are to be filled with fibrous or rubber-like fillers and the cylindrical assembly is to be sheathed with the appropriate protective covering. Fillers may be omitted in multi-core cables having conductor sections 0·007 sq. in. (4,5 sq. mm.) or less.

### Belted Cables

**806** Belted cables are to be constructed as non-belted cables except that an insulating wall is to be applied to the cabled cores before applying the protective covering. For rubber or PVC-insulated cables the common belt is to be rubber or PVC respectively which may or may not form one body with the fillers.

### Fillers

**807** When fibrous fillers are used they are to consist of jute or similar rovings (including asbestos, glass, &c.), and are to be resistant to moisture.

When rubber-like fillers are used they are to consist of rubber (including regenerated and/or unvulcanized rubber) compounds or plastic compounds.

### Sheaths and Protective Coverings

**808** Cables are to be protected by one or more of the following and the sheath or protective covering is to be compatible with the insulation :—

| | |
|---|---|
| Sheath | Lead-alloy sheath |
| | Copper sheath |
| | Non-metallic sheath |
| Protective Covering | Steel-wire armour |
| | Steel-tape armour |
| | Metal-braid armour (basket weave) |
| | Fibrous braid |

Unsheathed cables, e.g., rubber-insulated taped and braided or equivalent may be used only if installed in conduit.

(*a*) Lead-Alloy Sheath—This is to be one of the recommended lead alloys given in I.E.C. Publication 92.

(*b*) Copper—Copper sheath is permitted only for mineral-insulated cables.

(*c*) Metal-Braid Armour (Basket weave)—This is to be formed of galvanized steel, copper or copper alloy or aluminium alloy wires. Aluminium alloy is to be corrosion-resistant. The coverage density of the braid is to be such that the weight of the braid is at least 90 per cent of the weight of a tube of the same metal having an internal diameter equal to the internal diameter of the braid and a thickness equal to the diameter of one of the wires forming the braid.

(*d*) Steel-Wire Armour—This is to consist of galvanized-annealed-steel wires having an elongation at break of at least 12 per cent. The wires are to be applied over the bedding so as to form a uniformly cylindrical layer and so as to ensure adequate flexibility for the cable.

(*e*) Steel-Tape Armour—This is to consist of annealed-steel tape. In general the armour is to be formed of two tapes wound over the bedding in the same direction so that the gap in the first layer is not more than half the tape width and the second layer covers this gap with an overlap.

Note.—Armour is to be protected against corrosion where necessary. A protective bedding is to be inserted beneath armour (of any type). This may be textile tape or braid, PCP tape or other suitable material. Textile materials are to be treated against moisture.

(*f*) Non-Metallic Sheath—Polychloroprene compound and polyvinylchloride compound may be used for impervious sheaths. PVC sheaths are not to be applied direct to rubber insulated cables. For asbestos-varnished cambric cables, asbestos sheath is permissible.

(*g*) Fibrous Braid—Textile braid is to be of cotton, hemp, asbestos, glass, or other equivalent fibre and is to be of strength suitable for the size of the cable. It is to be effectively impregnated with a compound which is resistant to moisture, and flame retarding except where flame-extending cables are permitted by 812.

### Dimensions

**809** The thickness of insulation and sheath is to be generally in accordance with Tables 8.2 and 8.3.

The cables may be used in circuits in which the voltage between a conductor and the hull of the ship does not exceed the voltage at the head of the appropriate Table. In an insulated system the voltage between any conductor and the hull of the ship is assumed to be equal to the voltage between lines.

250 V cables may be used for any conductor of a three-phase, 440 V, alternating-current system with star point earthed.

Cables with other dimensions but which comply with a national specification for marine cables may be submitted for consideration.

### Choice of Cables

**810** The rated voltage of any cable is to be not lower than the nominal voltage of the circuit for which it is used.

Cables exposed to voltage surges associated with highly inductive circuits, e.g., contactor operating circuits for winches, etc., are to be at least 660 V grade.

The rated operating temperature of the insulating material is to be at least 10° C. (18° F.) higher than the maximum ambient temperature liable to be produced in the space where the cable is installed.

Polyvinylchloride insulation is not to be used where it is necessary for the cable to pass through watertight bulkhead glands. (*See also* 842.) Its use is to be restricted to the smaller sizes of cables (in general up to ·06 sq. in. or 35 sq. mm.).

TABLE 8.2

THICKNESS OF INSULATION

| Nominal cross section | | | Rubber | | P.V.C. | | Varnished Cambric | | | Asbestos-Varnished Cambric | | | | Mineral | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 250 V. | 660 V. | 250 V. | 660 V. | 1100 V. | | 3300 V. | 250 V. | | 660 V. | | 440 V. | 660 V. |
| | | | Radial | Radial | Radial | Radial | c/c | c/s | c/c; c/s | Radial Cambric | Radial Asbestos | Radial Cambric | Radial Asbestos | c/c; c/s | c/c; c/s |
| | sq. in. | sq. mm. | in. *mm.* | in. *mm.* | in. *mm.* | in. *mm.* | in. *mm.* | in. *mm.* | in. *mm.* | in. *mm.* | in. *mm.* | in. *mm.* | in. *mm.* | in. *mm.* | in. *mm.* |
| 1/·044 | ·0015 | | ·030 | ·055 | ·025 | ·035 | | | | ·018 | ·020 | ·030 | ·030 | ·040 | ·060 |
| | | 1 | *0,8* | *1,4* | *0,6* | *0,9* | | | | *0,45* | *0,5* | *0,8* | *0,8* | *1,0* | *1,5* |
| 3/·029 | ·002 | | ·030 | ·055 | ·025 | ·035 | | | | ·018 | ·020 | ·030 | ·030 | ·040 | ·060 |
| | | 1,5 | *0,8* | *1,4* | *0,6* | *0,9* | | | | *0,45* | *0,5* | *0,8* | *0,8* | *1,0* | *1,5* |
| 3/·036; 1/·064 | ·003 | | ·030 | ·055 | ·025 | ·035 | | | | ·018 | ·020 | ·030 | ·030 | ·040 | ·060 |
| | | 2,5 | *0,8* | *1,4* | *0,6* | *0,9* | | | | *0,45* | *0,5* | *0,8* | *0,8* | *1,0* | *1,5* |
| 7/·029 | ·0045 | | ·030 | ·055 | ·025 | ·035 | ·070 | ·055 | | ·018 | ·020 | ·030 | ·030 | ·040 | ·060 |
| | | 4 | *0,9* | *1,5* | *0,6* | *1,0* | *1,8* | *1,4* | | *0,45* | *0,5* | *0,8* | *0,8* | *1,0* | *1,5* |
| 7/·036 | ·007 | | ·035 | ·060 | ·030 | ·040 | ·070 | ·055 | | ·018 | ·020 | ·030 | ·030 | ·040 | ·060 |
| | | 6 | *0,9* | *1,5* | *0,8* | *1,0* | *1,8* | *1,4* | | *0,45* | *0,5* | *0,8* | *0,8* | | *1,5* |
| 7/·044 | ·01 | | ·035 | ·060 | ·030 | ·040 | ·070 | ·055 | | ·018 | ·020 | ·030 | ·030 | | ·060 |
| 7/·052 | ·0145 | | ·040 | ·060 | ·035 | ·040 | ·070 | ·055 | ·130 | ·018 | ·020 | ·030 | ·030 | | ·060 |
| | | 10 | *1,0* | *1,5* | *0,9* | *1,0* | *1,8* | *1,4* | *3,3* | *0,45* | *0,5* | *0,8* | *0,8* | | *1,5* |
| 7/·064 | ·0225 | | ·040 | ·060 | ·035 | ·040 | ·070 | ·055 | ·130 | ·018 | ·020 | ·030 | ·030 | | ·060 |
| | | 16 | *1,0* | *1,5* | *0,9* | *1,1* | *1,8* | *1,4* | *3,3* | *0,45* | *0,5* | *0,8* | *0,8* | | *1,5* |
| 19/·044 | ·03 | | ·045 | ·060 | ·040 | ·045 | ·070 | ·055 | ·130 | ·018 | ·020 | ·030 | ·030 | | ·060 |
| | | 25 | *1,2* | *1,6* | *1,0* | *1,3* | *1,8* | *1,4* | *3,3* | *0,45* | *0,5* | *0,8* | *0,8* | | *1,5* |
| 19/·052 | ·04 | | ·050 | ·065 | ·045 | ·050 | ·070 | ·055 | ·130 | ·018 | ·025 | ·030 | ·030 | | ·060 |
| | | 35 | *1,4* | *1,6* | | *1,3* | *1,8* | *1,4* | *3,3* | *0,45* | *0,6* | *0,8* | *1,2* | | *1,5* |
| 19/·064 | ·06 | | ·055 | ·065 | | ·050 | ·070 | ·055 | ·130 | ·018 | ·025 | ·030 | ·045 | | ·060 |
| | | 50 | | *1,7* | | | *1,8* | *1,4* | *3,3* | | | *0,8* | *1,2* | | *1,5* |
| | | 60 | | *1,7* | | | *1,8* | *1,4* | *3,3* | | | *0,8* | *1,2* | | *1,5* |
| 19/·083 | ·1 | | | ·070 | | | ·070 | ·055 | ·130 | | | ·030 | ·045 | | ·060 |
| | | 70 | | *1,8* | | | *1,8* | *1,4* | *3,3* | | | *0,8* | *1,2* | | *1,5* |
| | | 95 | | *2,0* | | | *1,8* | *1,4* | *3,3* | | | *0,8* | *1,2* | | *1,5* |
| 37/·072 | ·15 | | | ·080 | | | ·070 | ·055 | ·130 | | | ·030 | ·045 | | ·060 |
| | | 120 | | *2,3* | | | *1,8* | *1,4* | *3,3* | | | *0,8* | *1,9* | | *1,5* |
| 37/·083 | ·2 | | | ·090 | | | ·070 | ·055 | ·130 | | | ·030 | ·075 | | ·060 |
| | | 150 | | *2,4* | | | *1,8* | *1,4* | *3,3* | | | *0,8* | *1,9* | | *1,5* |
| 37/·093 | ·25 | | | ·095 | | | ·070 | ·055 | ·130 | | | ·030 | ·075 | | ·060 |
| | | 185 | | *2,5* | | | *1,8* | *1,4* | *3,3* | | | *0,8* | *1,9* | | *1,5* |
| 37/·103 | ·3 | | | ·100 | | | ·070 | ·055 | ·130 | | | ·030 | ·075 | | ·060 |
| | | 240 | | *2,7* | | | *1,9* | *1,5* | *3,3* | | | *0,8* | *1,9* | | *1,5* |
| 61/·093 | ·4 | | | ·110 | | | ·080 | ·065 | ·130 | | | ·030 | ·075 | | ·060 |
| | | 300 | | *3,0* | | | *2,0* | *1,6* | *3,3* | | | *0,8* | *1,9* | | *1,5* |
| 61/·103 | ·5 | | | ·120 | | | ·080 | ·065 | ·130 | | | ·030 | ·075 | | ·060 |
| | | 400 | | *3,2* | | | *2,0* | *2,0* | *3,3* | | | *0,8* | *1,9* | | *1,5* |
| 91/·103 | ·75 | | | ·130 | | | ·090 | ·080 | ·130 | | | ·030 | ·075 | | ·060 |
| | | 500 | | *3,3* | | | *2,3* | *2,0* | *3,3* | | | *0,8* | *1,9* | | *1,5* |
| | | 625 | | *3,5* | | | *2,5* | *2,3* | *3,3* | | | *0,8* | *1,9* | | *1,5* |
| 127/·103 | 1·0 | | | ·140 | | | ·100 | ·090 | ·130 | | | ·030 | ·075 | | ·060 |

c/c = between conductors c/s = between conductor and sheath.

NOTE.—Rubber and P.V.C. thicknesses are the average of a number of measurements.
Tolerance on declared values:— Rubber 5%+·005 in. (0,13 mm.) P.V.C. up to ·050 in. (1,3 mm.) 5%+·003 in. (0,076 mm.).

TABLE 8.3

THICKNESS OF SHEATH

| Diameter under Sheath | | Thickness of Sheath (Average) | | |
|---|---|---|---|---|
| Above | Up to and including | Rubber or P.C.P. | P.V.C. | Lead Alloy |
| in.<br>*mm.* | in.<br>*mm.*<br>0·25<br>*6,0* | in.<br>*mm.*<br>·040<br>*1,0* | in.<br>*mm.*<br>·035<br>*0,9* | in.<br>*mm.*<br>·040<br>*1,0* |
| ·25<br>*6,0* | ·5<br>*12,0* | ·050<br>*1,3* | ·045<br>*1,15* | ·045<br>*1,15* |
| ·5<br>*12,0* | ·75<br>*19,0* | ·060<br>*1,5* | ·055<br>*1,4* | ·055<br>*1,4* |
| ·75<br>*19,0* | 1·0<br>*25,0* | ·070<br>*1,8* | ·070<br>*1,8* | ·065<br>*1,65* |
| 1·0<br>*25,0* | 1·25<br>*31,0* | ·080<br>*2,0* | ·080<br>*2,0* | ·075<br>*1,9* |
| 1·25<br>*31,0* | 1·5<br>*38,0* | ·090<br>*2,3* | ·090<br>*2,3* | ·085<br>*2,15* |
| 1·5<br>*38,0* | 1·75<br>*44,0* | ·100<br>*2,5* | ·100<br>*2,5* | ·095<br>*2,4* |
| 1·75<br>*44,0* | 2·0<br>*51,0* | ·110<br>*2,8* | ·110<br>*2,8* | ·105<br>*2,65* |
| 2·0<br>*51,0* | 2·25<br>*57,0* | ·120<br>*3,0* | ·120<br>*3,0* | ·115<br>*2,9* |
| 2·25<br>*57,0* | 2·5<br>*63,0* | ·130<br>*3,3* | ·130<br>*3,3* | ·125<br>*3,15* |
| 2·5<br>*63,0* | 2·75<br>*70,0* | ·140<br>*3,5* | ·140<br>*3,5* | ·135<br>*3,4* |
| 2·75<br>*70,0* | 3·0<br>*76,0* | ·150<br>*3,8* | ·150<br>*3,8* | ·145<br>*3,7* |
| 3·0<br>*76,0* | 3·25<br>*82,0* | ·160<br>*4,0* | ·160<br>*4,0* | ·155<br>*3,9* |

Tolerances on declared values:—

| | |
|---|---|
| P.C.P. | 5%+·010 in. (0,25 mm.) |
| P.V.C. Up to and including ·075 in. (1,9 mm.) | 5%+·007 in. (0,18 mm.) |
| Above ·075 in. (1,9 mm.) | 5%+·010 in. (0,25 mm.) |
| Lead Alloy | 5%+·005 in. (0,13 mm.) |

For lead-alloy sheath, if the minimum at a point method of measurement is preferred the thickness of sheath is to be at least the values given above reduced by ·010 in. (0,25 mm.)

### Choice of Protective Covering

**811** Cables fitted in the following locations:—

Decks exposed to the weather
Bathrooms
Cargo holds
Refrigerated spaces
Machinery spaces

or in any other location where water condensation or harmful vapour (e.g., oil vapour) may be present are to have an impervious sheath. In permanently wet situations metallic sheaths are to be used for cables with hygroscopic insulation.

**812** All cables are to be of flame-retardant or fire-resisting types (*see* 850) except that flame-extending cables may be used for final circuits only in the following cases:—

(*a*) Where cables are installed in metallic conduits having an internal diameter not exceeding 1 in. (25 mm.) and provided the conduits are mechanically and electrically continuous.

(*b*) Bare lead sheathed cable having conductor sections not exceeding 0·007 sq. in. (4,5 sq. mm.).

### Current Rating

**813** The highest continuous load carried by a cable is not to exceed its current rating. The diversity factor of the individual loads and the duration of the maximum demand may be allowed for in estimating the maximum continuous load and is to be shown on plans submitted for approval.

The voltage drop from the main switchboard busbars to any point in the installation when the cables are carrying maximum current under normal conditions of service, is not to exceed 6 per cent of the nominal voltage.

In assessing the current rating of lighting circuits every lampholder is to be assessed at the maximum load likely to be connected to it, with a minimum of 60 watts, unless the fitting is so constructed as to take only a lamp rated at less than 60 watts.

Cables supplying cargo winches, cranes, windlasses and capstans are to be suitably rated for their duty. Unless the duty is such as to require a longer time rating cables for winch or crane motors may be half hour rated on the basis of the half hour b.h.p. of the motors. Cables for windlass and capstan motors are to be not less than one hour rated on the basis of the one hour b.h.p. of the motor. In all cases the rating is to be subject to the voltage drop being within the specified limits.

The following Table 8.4 gives the maximum permissible continuous-current rating for single- and multi-core cables, except that where a more precise evaluation of current rating has been carried out based on experimental or calculated data details may be submitted for approval.

## CURRENT RATING IN AMPERES

(Based on ambient temperature 45° C.)

TABLE 8.4 (a)—GENERAL PURPOSE RUBBER AND P.V.C.

| Nominal cross section | | | Single core | 2 core | 3 or 4 core |
|---|---|---|---|---|---|
| | sq. in. | sq. mm. | | | |
| 1/·044 | ·0015 | | 9 | 7 | 6 |
| | | 1 | 9 | 7 | 6 |
| 3/·029 | ·002 | | 11 | 9 | 7 |
| | | 1,5 | 12 | 10 | 8 |
| 3/·036; 1/·064 | ·003 | | 14 | 11 | 9 |
| | | 2,5 | 17 | 14 | 11 |
| 7/·029 | ·0045 | | 18 | 16 | 13 |
| | | 4 | 23 | 19 | 16 |
| 7/·036 | ·007 | | 25 | 21 | 17 |
| | | 6 | 30 | 25 | 21 |
| 7/·044 | ·01 | | 31 | 26 | 22 |
| 7/·052 | ·0145 | | 37 | 31 | 26 |
| | | 10 | 41 | 34 | 28 |
| 7/·064 | ·0225 | | 51 | 43 | 35 |
| | | 16 | 54 | 45 | 37 |
| 19/·044 | ·03 | | 60 | 51 | 42 |
| | | 25 | 70 | 59 | 49 |
| 19/·052 | ·04 | | 72 | 61 | 50 |
| | | 35 | 86 | 73 | 60 |
| 19/·064 | ·06 | | 92 | 78 | 64 |
| | | 50 | 105 | 91 | 75 |
| | | 60 | 120 | 100 | 84 |
| 19/·083 | ·1 | | 125 | 105 | 87 |
| | | 70 | 130 | 110 | 91 |
| | | 95 | 160 | 135 | 110 |
| 37/·072 | ·15 | | 160 | 135 | 110 |
| | | 120 | 180 | 155 | 130 |
| 37/·083 | ·2 | | 190 | 160 | 135 |
| | | 150 | 210 | 180 | 145 |
| 37/·093 | ·25 | | 220 | 185 | 155 |
| | | 185 | 240 | 205 | 170 |
| 37/·103 | ·3 | | 250 | 210 | 175 |
| | | 240 | 280 | 240 | 200 |
| 61/·093 | ·4 | | 300 | 255 | 210 |
| | | 300 | 325 | 275 | 225 |
| 61/·103 | ·5 | | D.C. 340 A.C. | D.C. 290 A.C. | D.C. 240 A.C. |
| | ·6 | | 380 375 | 325 320 | 265 265 |
| | | 400 | 390 385 | 330 325 | 275 270 |
| 91/·103 | ·75 | | 445 420 | 375 360 | 310 295 |
| | | 500 | 450 430 | 380 365 | 315 300 |
| | | 625 | 520 470 | 440 375 | 360 330 |
| 127/·103 | 1·0 | | 530 480 | 450 405 | 370 335 |

TABLE 8.4 (b)—HEAT RESISTING RUBBER

| Nominal cross section | | | Single core | 2 core | 3 or 4 core |
|---|---|---|---|---|---|
| | sq. in. | sq. mm. | | | |
| 1/·044 | ·0015 | 1 | 14 | 11 | 9 |
| | | | 14 | 11 | 9 |
| 3/·029 | ·002 | | 17 | 14 | 11 |
| 3/·036; 1/·064 | ·003 | 1,5 | 19 | 16 | 13 |
| | | | 21 | 17 | 14 |
| | | 2,5 | 25 | 21 | 17 |
| 7/·029 | ·0045 | 4 | 27 | 23 | 18 |
| | | | 32 | 27 | 22 |
| 7/·036 | ·007 | | 35 | 29 | 24 |
| 7/·044 | ·01 | 6 | 42 | 35 | 29 |
| | | | 44 | 37 | 30 |
| 7/·052 | ·0145 | | 55 | 46 | 38 |
| 7/·064 | ·0225 | 10 | 58 | 49 | 40 |
| | | | 74 | 62 | 51 |
| | | 16 | 78 | 66 | 54 |
| 19/·044 | ·03 | 25 | 87 | 74 | 61 |
| | | | 100 | 86 | 71 |
| 19/·052 | ·04 | | 105 | 89 | 73 |
| 19/·064 | ·06 | 35 | 125 | 105 | 88 |
| | | | 135 | 115 | 94 |
| | | 50 | 155 | 135 | 110 |
| 19/·083 | ·1 | 60 | 175 | 150 | 125 |
| | | | 185 | 155 | 130 |
| | | 70 | 195 | 165 | 135 |
| 37/·072 | ·15 | 95 | 235 | 200 | 160 |
| | | | 235 | 200 | 165 |
| | | 120 | 270 | 230 | 190 |
| 37/·083 | ·2 | 150 | 285 | 240 | 200 |
| | | | 310 | 265 | 215 |
| 37/·093 | ·25 | | 325 | 275 | 225 |
| 37/·103 | ·3 | 185 | 355 | 300 | 250 |
| | | | 365 | 310 | 255 |
| | | 240 | 415 | 355 | 290 |
| 61/·093 | ·4 | 300 | 435 | 370 | 305 |
| | | | 480 | 410 | 335 |
| 61/·103 | ·5 | | D.C. 500 A.C. | D.C. 425 A.C. | D.C. 350 A.C. |
| 91/·103 | ·6 | 400 | 560 550 | 475 465 | 390 385 |
| | | | 570 560 | 485 475 | 400 390 |
| | ·75 | | 640 610 | 540 520 | 450 425 |
| 127/·103 | 1·0 | 500 | 650 620 | 550 530 | 455 435 |
| | | | 740 670 | 630 570 | 520 470 |
| | | 625 | 760 690 | 650 580 | 530 480 |

TABLE 8.4 (c)—VARNISHED CAMBRIC, BUTYL

| Nominal cross section | | | Single core | 2 core | 3 or 4 core |
|---|---|---|---|---|---|
| | sq. in. | sq. mm. | | | |
| 1/·044 | ·0015 | | 15 | 12 | 10 |
| | | 1 | 15 | 12 | 10 |
| 3/·029 | ·002 | | 19 | 16 | 13 |
| | | 1,5 | 21 | 17 | 14 |
| 3/·036; 1/·064 | ·003 | | 23 | 19 | 16 |
| | | 2,5 | 27 | 22 | 18 |
| 7/·029 | ·0045 | | 29 | 24 | 20 |
| | | 4 | 35 | 29 | 24 |
| 7/·036 | ·007 | | 38 | 32 | 26 |
| | | 6 | 45 | 38 | 31 |
| 7/·044 | ·01 | | 48 | 40 | 33 |
| 7/·052 | ·0145 | | 60 | 51 | 42 |
| | | 10 | 63 | 53 | 44 |
| 7/·064 | ·0225 | | 78 | 66 | 54 |
| | | 16 | 83 | 70 | 58 |
| 19/·044 | ·03 | | 93 | 79 | 65 |
| | | 25 | 110 | 93 | 77 |
| 19/·052 | ·04 | | 115 | 96 | 79 |
| | | 35 | 135 | 115 | 94 |
| 19/·064 | ·06 | | 145 | 120 | 100 |
| | | 50 | 170 | 145 | 115 |
| | | 60 | 185 | 160 | 130 |
| 19/·083 | ·1 | | 195 | 165 | 135 |
| | | 70 | 205 | 175 | 145 |
| | | 95 | 250 | 215 | 175 |
| 37/·072 | ·15 | | 255 | 215 | 180 |
| | | 120 | 290 | 245 | 205 |
| 37/·083 | ·2 | | 300 | 255 | 210 |
| | | 150 | 335 | 285 | 235 |
| 37/·093 | ·25 | | 345 | 295 | 240 |
| | | 185 | 380 | 320 | 265 |
| 37/·103 | ·3 | | 390 | 330 | 270 |
| | | 240 | 445 | 380 | 310 |
| 61/·093 | ·4 | | 465 | 395 | 325 |
| | | 300 | 510 | 435 | 355 |
| 61/·103 | ·5 | | D.C. 530 A.C. | D.C. 450 A.C. | D.C. 370 A.C. |
| | ·6 | | 600 585 | 510 495 | 420 410 |
| | | 400 | 610 590 | 520 500 | 425 415 |
| 91/·103 | ·75 | | 680 640 | 580 540 | 475 450 |
| | | 500 | 690 640 | 590 550 | 485 450 |
| | | 625 | 790 680 | 680 580 | 550 480 |
| 127/·103 | 1·0 | | 810 690 | 690 590 | 570 485 |

TABLE 8.4 (d) ASBESTOS-VARNISHED CAMBRIC

| Nominal cross section | | | Single core | 2 core | 3 or 4 core |
|---|---|---|---|---|---|
| | sq. in. | sq. mm. | | | |
| 1/·044 | ·0015 | 1 | 16 | 13 | 11 |
| | | | 16 | 13 | 11 |
| 3/·029 | ·002 | | 20 | 17 | 14 |
| 3/·036; 1/·064 | ·003 | 1,5 | 22 | 18 | 15 |
| | | | 25 | 21 | 17 |
| | | 2,5 | 28 | 23 | 19 |
| 7/·029 | ·0045 | 4 | 31 | 26 | 22 |
| | | | 37 | 31 | 25 |
| 7/·036 | ·007 | | 41 | 34 | 28 |
| 7/·044 | ·01 | 6 | 48 | 40 | 33 |
| | | | 51 | 43 | 35 |
| 7/·052 | ·0145 | | 64 | 54 | 44 |
| 7/·064 | ·0225 | 10 | 67 | 57 | 47 |
| | | | 83 | 70 | 58 |
| | | 16 | 89 | 75 | 62 |
| 19/·044 | ·03 | 25 | 99 | 84 | 69 |
| | | | 115 | 99 | 82 |
| 19/·052 | ·04 | | 120 | 105 | 94 |
| 19/·064 | ·06 | 35 | 145 | 120 | 100 |
| | | | 155 | 130 | 110 |
| | | 50 | 180 | 155 | 125 |
| 19/·083 | ·1 | 60 | 200 | 170 | 140 |
| | | | 210 | 180 | 145 |
| | | 70 | 220 | 185 | 155 |
| 37/·072 | ·15 | 95 | 270 | 220 | 190 |
| | | | 270 | 230 | 190 |
| | | 120 | 310 | 265 | 215 |
| 37/·083 | ·2 | 150 | 320 | 270 | 225 |
| | | | 355 | 305 | 250 |
| 37/·093 | ·25 | | 370 | 315 | 260 |
| 37/·103 | ·3 | 185 | 405 | 345 | 285 |
| | | | 415 | 355 | 290 |
| | | 240 | 475 | 405 | 330 |
| 61/·093 | ·4 | 300 | 495 | 425 | 350 |
| | | | 540 | 465 | 380 |
| 61/·103 | ·5 | | D.C. 570 A.C. | D.C. 480 A.C. | D.C. 400 A.C. |
| 91/·103 | ·6 | 400 | 640 620 | 545 530 | 450 435 |
| | | | 650 630 | 550 540 | 455 440 |
| | ·75 | | 730 680 | 620 580 | 510 475 |
| 127/·103 | 1·0 | 500 | 740 690 | 630 590 | 520 480 |
| | | | 850 730 | 720 620 | 590 510 |
| | | 625 | 870 740 | 740 630 | 610 520 |

TABLE 8.4 (e) SILICONE RUBBER, MINERAL

| Nominal cross section | | | Single core | 2 core | 3 or 4 core |
|---|---|---|---|---|---|
| | sq. in. | sq. mm. | | | |
| 1/·044 | ·0015 | | 19 | 16 | 13 |
| | | 1 | 20 | 17 | 14 |
| 3/·029 | ·002 | | 23 | 19 | 16 |
| | | 1,5 | 25 | 21 | 17 |
| 3/·036; 1/·064 | ·003 | | 27 | 23 | 18 |
| | | 2,5 | 31 | 26 | 21 |
| 7/·029 | ·0045 | | 34 | 29 | 23 |
| | | 4 | 41 | 35 | 28 |
| 7/·036 | ·007 | | 44 | 37 | 30 |
| | | 6 | 53 | 45 | 37 |
| 7/·044 | ·01 | | 56 | 47 | 39 |
| 7/·052 | ·0145 | | 70 | 59 | 49 |
| | | 10 | 73 | 62 | 51 |
| 7/·064 | ·0225 | | 93 | 79 | 65 |
| | | 16 | 99 | 84 | 69 |
| 19/·044 | ·03 | | 110 | 93 | 77 |
| | | 25 | 130 | 110 | 92 |
| 19/·052 | ·04 | | 135 | 115 | 94 |
| | | 35 | 165 | 140 | 115 |
| 19/·064 | ·06 | | 175 | 150 | 125 |
| | | 50 | 205 | 175 | 145 |
| | | 60 | 230 | 195 | 160 |
| 19/·083 | ·1 | | 240 | 205 | 170 |
| | | 70 | 255 | 215 | 175 |
| | | 95 | 310 | 265 | 215 |
| 37/·072 | ·15 | | 315 | 265 | 220 |
| | | 120 | 360 | 305 | 250 |
| 37/·083 | ·2 | | 380 | 325 | 265 |
| | | 150 | 420 | 355 | 290 |
| 37/·093 | ·25 | | 440 | 375 | 310 |
| | | 185 | 485 | 410 | 340 |
| 37/·103 | ·3 | | 500 | 425 | 350 |
| | | 240 | 570 | 485 | 400 |
| 61/·093 | ·4 | | 600 | 510 | 420 |
| | | 300 | 660 | 560 | 460 |
| 61/·103 | ·5 | | 690 | 590 | 485 |

### Correction Factors for Current Rating

**814** (*a*) BUNCHING OF CABLES—Where more than six cables belonging to the same circuit are bunched together a correction factor of 0,85 is to be applied.

(*b*) AMBIENT TEMPERATURE—When it is known that the ambient temperature is different from that given in M 106 the following correction factors are to be applied.

TABLE 8.5

| Insulation | Correction Factor for Ambient Temperature | | | |
|---|---|---|---|---|
| | 40°C. (104°F.) | 45°C. (113°F.) | 50°C. (122°F.) | 55°C. (131°F.) |
| Rubber or P.V.C. (general purpose) ... ... ... | 1·15 | 1·00 | 0·82 | — |
| Rubber (heat-resisting quality) ... ... ... | 1·08 | 1·00 | 0·91 | 0·82 |
| Varnished Cambric ... | 1·07 | 1·00 | 0·93 | 0·85 |
| Asbestos-Varnished Cambric | 1·06 | 1·00 | 0·94 | 0·87 |
| Mineral, Silicone Rubber... | 1·05 | 1·00 | 0·95 | 0·89 |

(*c*) INTERMITTENT SERVICE—Where the load is intermittent the correction factors in Table 8.6 may be applied for half hour and one hour ratings. In no case is a shorter rating than one half hour rating to be used, whatever the degree of intermittency.

### Installation of Cables

**815** Cable runs are to be, as far as possible, straight and accessible.

**816** The installation of cables across expansion joints in the ship's structure is to be avoided. Where this is not practicable a loop of cable of length proportional to the expansion of the joint is to be provided. The internal radius of the loop is to be at least 12 times the external diameter of the cable.

**817** Where a duplicate supply is required the two cables are to follow different routes which are to be as far apart as practicable.

**818** Cables having insulating materials with different maximum-rated conductor temperatures are not to be bunched together, or, where this is not practicable, the cables are to be operated so that no cable

TABLE 8.6

| Correction Factor | Half Hour Rating | | One Hour Rating | |
|---|---|---|---|---|
| | With Metallic Sheath | Without Metallic Sheath | With Metallic Sheath | Without Metallic Sheath |
| 1·0 | Up to ·03 sq. in. 20 sq. mm. | Up to ·1 sq. in. 75 sq. mm. | Up to ·1 sq. in. 67 sq. mm. | Up to ·3 sq. in. 230 sq. mm. |
| 1·1 | ·04–·06 sq. in. 21–40 sq. mm. | ·15 sq. in. 76–125 sq. mm. | ·15–·25 sq. in. 68–170 sq. mm. | ·4–·6 sq. in. 231–400 sq. mm. |
| 1·15 | ·1 sq. in. 41–65 sq. mm. | ·2–·25 sq. in. 126–180 sq. mm. | ·3–·4 sq. in. 171–290 sq. mm. | ·75–1·0 sq. in. 401–600 sq. mm. |
| 1·2 | 66–95 sq. mm. | ·3 sq. in. 181–250 sq. mm. | ·5–·6 sq. in. 291–430 sq. mm. | |
| 1·25 | ·15–·2 sq. in. 96–130 sq. mm. | ·4 sq. in. 251–320 sq. mm. | ·75–1·0 sq. in. 431–600 sq. mm. | |
| 1·3 | ·25 sq. in. 131–170 sq. mm. | ·5–·6 sq. in. 321–400 sq. mm. | | |
| 1·35 | ·3 sq. in. 171–220 sq. mm. | ·75 sq. in. 401–500 sq. mm. | | |
| 1·4 | ·4 sq. in. 221–270 sq. mm. | | | |

reaches a temperature higher than that permitted for the lowest temperature-rated cable in the group.

**819** Cables having a protective covering which may damage the covering of other cables are not to be bunched with those other cables.

**820** When installing cables the minimum internal radius of bend is to be generally in accordance with :—

6 d for rubber and PVC cables with metal covering
6 d for rubber and PVC cables exceeding 1 in. (25,4 mm.) diameter and without metal covering
4 d for rubber and PVC cables exceeding ·375 in. (9,5 mm.) diameter and without metal covering
8 d for varnished cambric cables
4 d for mineral-insulated cables

(d=overall diameter of cable)

### Mechanical Protection

**821** Cables exposed to risk of mechanical damage are to be protected by metal channels or casing or enclosed in steel conduit unless the protective covering (e.g., armour or sheath) is sufficient to withstand the possible damage.

**822** Cables in cargo holds and other spaces where there is exceptional risk of mechanical damage are to be suitably protected, even if armoured, unless the steel structure affords adequate protection. (*See also* M 1613.)

**823** Metal casings for mechanical protection of cables are to be efficiently protected against corrosion.

### Earthing

**824** Metal coverings of cables are to be effectively earthed at both ends of the cable, except in final sub-circuits where earthing at the supply end only will be considered adequate.

**825** The electrical continuity of all metal coverings of cables throughout the length of the cable, particularly at joints and tappings is to be ensured.

**826** The lead sheath of lead-sheathed cables is not to be used as the sole means of earthing the non-current carrying parts of items of equipment.

### Securing of Cables

**827** Cables are to be effectively supported and secured without their coverings being damaged.

**828** The distances between supports is to be chosen according to the type of cable, the distances being generally in accordance with Table 8.7 below.

**829** Supports and accessories are to be robust and are to be of corrosion-resistant material or suitably corrosion inhibited before erection.

### Penetration of Bulkheads and Decks

**830** Penetration of watertight bulkheads or decks is to be carried out with either individual watertight glands or with packed watertight boxes carrying several cables. However carried out the watertight integrity of the bulkheads or deck is to be maintained. (*See also* 810.)

**831** Cables passing through decks are to be protected by deck tubes or ducts.

**832** Where cables pass through non-watertight bulkheads or structural steel the holes are to be bushed with lead or other approved material. If the steel is ·25 in. (6 mm.) thick, adequately rounded edges may be accepted as the equivalent of bushing.

**833** Materials used for glands and bushings are to be such that there is no risk of corrosion.

**834** Where rectangular holes are cut in bulkheads or structural steel the corners are to be radiused.

TABLE 8.7

| External diameter of Cable | | Non-Armoured Cables | Armoured Cables |
|---|---|---|---|
| Exceeding | Not Exceeding | | |
| — | 0·3 in. (7,6 mm.) | 8 in. (20 cm.) | 10 in. (25 cm.) |
| 0·3 in. (7,6 mm.) | 0·5 in. (12,7 mm.) | 10 in. (25 cm.) | 12 in. (30 cm.) |
| 0·5 in. (12,7 mm.) | 0·75 in. (20 mm.) | 12 in. (30 cm.) | 14 in. (35 cm.) |
| 0·75 in. (20 mm.) | 1·25 in. (30 mm.) | 14 in. (35 cm.) | 16 in. (40 cm.) |
| 1·25 in. (30 mm.) | — | 16 in. (40 cm.) | 18 in. (45 cm.) |

### Installation in Pipes and Conduits

If installed in pipe or conduit the following rules are to be complied with.

**835** Metal conduit systems are to be earthed and are to be mechanically and electrically continuous across joints. Individual short lengths of conduit need not be earthed.

**836** The internal radius of bend of pipes and conduit is to be not less than that laid down for cables provided that for pipes exceeding 2·5 in. (64 mm.) diameter the internal radius of bend is not less than twice the diameter of the pipe.

**837** The drawing-in factor (ratio of the sum of the cross sectional areas of the cables to the internal cross sectional area of the pipe) is not to exceed 0,4.

**838** Expansion joints are to be provided where necessary.

**839** Where necessary, ventilation openings are to be provided at the highest and lowest points so as to permit air circulation and to prevent accumulation of water.

Where cables are laid in trunks the trunks are to be so constructed as not to afford passage for fire from one between deck or compartment to another.

**840** High voltage cables, e.g., those used for cold cathode luminous discharge lamps, are not to be installed in metal conduit unless protected by metal sheath or screen.

**841** Non-metallic ducting or conduit is to be of flame-retardant material. PVC conduit is not to be used in refrigerated spaces or on open decks, unless specially approved.

### Installation in Refrigerated Spaces

**842** Cables installed in refrigerated spaces are to have a watertight or impervious sheath and are to be protected against mechanical damage. If an armoured cable is used the armour, unless galvanized, is to be protected against corrosion by a further moisture-resisting covering.

Cables entering a refrigerated space are to pass directly through the walls or lagging and are to be protected by a tube sealed at each end. Alternatively, the cables may be passed through solid door frames the necessary holes being sealed at each end.

Cables installed in a refrigerated space are not to be embedded in the walls or lagging.

Precautions are to be taken to prevent the placing of hooks round the cable as a casual means of suspension.

PVC insulated cables are not to be used in refrigerated spaces.

### Cables for Alternating Current

**843** Where it is necessary to use single-core cables for alternating-current circuits rated in excess of 20 A the following rules are to be complied with :—

(*a*) Cables are to be either non-armoured or armoured with non-magnetic material.

(*b*) If installed in pipe or conduit, cables belonging to the same circuit are to be installed in the same conduit, unless the conduit or pipe is of non-magnetic material.

(*c*) Cable clips are to include cables of all phases of a circuit unless the clips are of non-magnetic material.

(*d*) When installing two, three or four single-core cables forming respectively single-phase circuits, three-phase circuits or three-phase and neutral circuits the cables are to be in contact with one another, as far as possible. In any event the distance between adjacent cables is not to be greater than 1 diameter.

(*e*) If single-core cables, of current rating greater than 250 A are run along a steel bulkhead wherever practicable the cables should be spaced away from the steel.

(*f*) Where single core cables of rating exceeding 50 A are used, magnetic material is not to be placed between single-core cables of a group. If these cables pass through steel plates, all cables of the same circuit are to pass through a plate or gland so constructed that there is no magnetic material between the cables and suitable clearance is provided between the cable core and magnetic material. This clearance, wherever practicable, is to be not less than 3 in. (75 mm.) when the current exceeds 300 A. For currents between 50 A and 300 A the clearance is to be obtained by interpolation.

### Cable Ends

**844** The ends of all conductors of cross-sectional area greater than 0·0065 sq. in. (4 sq. mm.) are to be fitted with soldering sockets, compression type sockets or mechanical clamps. Corrosive fluxes are not to be used.

Cables having a hygroscopic insulation (e.g., varnished cambric or mineral insulated) are to have their ends sealed against ingress of moisture.

Cables with a supplementary insulating belt beneath the protective sheath are to have additional insulation at those points where the insulation of each core makes or may make contact with earthed metal.

### Joints and Branch Circuits

**845** If a joint is necessary it is to be carried out so that all conductors are adequately secured, insulated and protected from atmospheric action. Terminals or busbars are to be of dimensions adequate for the cable rating.

### Testing

**846** The following tests are to be made at the manufacturers' works prior to despatch and may be required to be carried out under the supervision of the Surveyors.

All main cable for electric propelling machinery is to be tested in the presence of the Surveyors. (*See* M 1701.)

### High Voltage Test

**847** The test is to be carried out on finished cables with either direct-current or single-phase alternating-current at the manufacturers' discretion. The power available in the test equipment is to be sufficient to maintain in the cable the specified test voltage and the charging current. The voltage is to be applied gradually so as to arrive at the specified figure in approximately one minute. The test voltage is to be applied as follows :—

For cables with metallic covering the test voltage is to be applied between conductor(s) and the metallic covering. For cables with non-metallic impervious sheath the voltage is to be applied between conductor(s) and the water in which the cable is to be immersed for at least one hour before the test. For cables having a non-metallic covering which might be impaired if immersed in water, the voltage is to be applied to samples, at least 40 in. (1 m.) long, the surface being covered with metal foil. In addition, for multi-core cables the voltage is to be applied in turn between each conductor and all other conductors connected together.

The test voltage in all cases is to be applied for 5 minutes, without failure, the value being in accordance with :—

TABLE 8.8

| Rated Voltage of Cable | | Test Voltage | |
|---|---|---|---|
| Above | Up to and including | A.C. Volts | D.C. Volts |
| | 250 | 1500 | 3000 |
| 250 | 750 | 2500 | 5000 |
| 750 | 1100 | 3000 | 6000 |
| 1100 | 3300 | 10000 | 20000 |
| 3300 | 6600 | 16000 | 32000 |

NOTE.—For mineral insulated cables having a rated voltage up to and including 440 V the test voltage is to be 2000 V alternating current and for voltages above 440 V the test voltage is to be 3000 V alternating current.

### Insulation Resistance

**848** Immediately after the high voltage test the insulation resistance is to be measured and recorded, using a direct-current voltage of at least 400 V and the measurement being made after electrification for 1 minute. (*See also* M 1902.)

### Spark Testing

**849** Spark testing may be accepted as an alternative to the high voltage and insulation resistance test for cables with rubber or rubber-like insulation. The test is to be made at the core stage except for single core braided and compounded cables which may be tested at the finished stage.

The core or cable is to withstand the test voltage without failure and the speed at which the cable passes through the electrode is to be such that every point is in contact with the electrode for not less than 0·1 sec. Test voltages are given in Table 8.9.

TABLE 8.9

| Rated Voltage of Cable V | Conductor Sectional Area | | Test Voltage (r.m.s.) kV |
|---|---|---|---|
| | Above | Up to and including | |
| 250 | — | ·0225 sq. in. (16 sq. mm.) | 6 |
| | ·0225 sq. in. (16 sq. mm.) | ·04 sq. in. (25 sq. mm). | 8 |
| | ·04 sq. in. (25 sq. mm.) | | 10 |
| 660 | — | ·04 sq. in. (25 sq. mm.) | 10 |
| | ·04 sq. in. (25 sq. mm.) | | 12 |

**Flame-Extending, Flame-Retardant and Fire-Resisting Cables**

**850** A sample of cable 48 in. (1,2 m.) long is to be clamped vertically in a three-sided enclosure with open top, of size suitable to contain the cable. A bunsen burner of nominal bore $\frac{3}{8}$ in. (10 mm.) fed with ordinary illuminating gas at normal pressure, giving a flame approximately 5 in. (125 mm.) long with an inner blue cone approximately 1·5 in. (40 mm.) long, is to be applied to the cable so that the tip of the blue cone touches the cable at approximately 12 in. (0,4 m.) from its lower end. The burner is to be held at 45° to the vertical and the flame applied for a time

$$t \text{ (secs)} = 10 + \frac{W}{50}$$

where W=weight of cable sample in grams.
The application is not to be continuous but in steps of 10 seconds, with 10 seconds interruption between applications.

At the end of this period the burner is to be removed and cables are to be graded as follows:—

(*a*) Flame extending when the flame travels along the whole length of the specimen.

(*b*) Flame retardant when the flame extinguishes before reaching the top of the specimen.

(*c*) Fire resisting when, in addition to (b) the specimen is able to withstand after cooling an alternating-current test voltage of twice its rated voltage for 1 minute.

NOTE.—To ensure correct heat in the gas flame a bare copper wire 0·028 in. (0,7 mm.) diameter and of length 4 in. (100 mm.) is to be inserted horizontally in the flame and 2 in. (50 mm.) above the top of the burner, so that the free end of the wire is vertically above the edge of the burner on the side of the burner remote from the supported end of the wire. If the wire takes more than 6 seconds to melt then the flame is not hot enough for the test.

Other tests which are the equivalent of the above may be submitted for consideration.

**Quality of Materials**

**851** The quality of materials is to be in accordance with the recommendations of I.E.C. Publication 92.

Alternative requirements of National Standards will be considered.

## Section 9

### TRANSFORMERS

**901** The following Rules apply to all transformers for general use rated from 1 kVA to 1000 kVA inclusive and suitable for operating over an input voltage range up to 3300 volts line to line.

Transformers outside these limits will be specially considered.

**Construction**

**902** Transformers except those for motor starting are to be double wound.

**Liquid Cooled Transformers**

**903** Proposals for the use of liquid cooled transformers will be specially considered.

**Number and Rating of Transformers**

**904** Where essential services are supplied the number and ratings of transformers are to be sufficient to ensure the operation of essential services even when one transformer is out of service.

**Regulation**

**905** The inherent regulation at 0·8 power factor is not to exceed 5 per cent.

Regulation of the complete system is to comply with M 813.

**Temperature Rise**

**906** The temperature rise of windings of dry type transformers above the ambient temperatures given in M 106, when measured by resistance, during continuous operation at the maximum rating is not to exceed:—

Class A 50° C.
Class B 70° C.

Proposals to use Class H or Class C insulation will be specially considered.

**Short Circuit**

**907** All transformers are to be capable of withstanding, without damage, the thermal and mechanical effects of a short-circuit at the terminals of any winding for 2 secs.

**Tests**

**908** The following tests are to be carried out on all transformers at the manufacturers' works, and a certificate of tests issued by the manufacturer.

HIGH VOLTAGE TEST

(*a*) The voltage is to be applied to each winding in turn, between the winding under test and the remaining windings, core, frame and tank or casing connected together and to earth.

The test is to be made with 1 kV a.c. plus twice the highest voltage between lines with a minimum of

2·5 kV at any frequency between 25 c/s and 100 c/s and maintained for 1 minute without failure.

INDUCED HIGH VOLTAGE TEST

(*b*) To test between turns, coils and terminals an a.c. voltage is to be applied between the above parts corresponding to twice the voltage appearing between these parts when rated voltage is applied to the terminals. The duration of the test is to be 1 minute for any test frequency up to and including twice the rated frequency.

INSULATION RESISTANCE

(*c*) The insulation resistance of each winding in turn to all the other windings, core, frame and tank or casing connected together and to earth is to be measured and recorded together with the temperature of the transformer at the time of the test.

TEMPERATURE RISE

(*d*) One transformer of each size and type is to be given a temperature rise test.

## Section 10

### LIGHTING

**1001** Lighting which is essential for the safety and the working of the ship is to comply with the following Rules :—

The voltage of tungsten filament lampholders is not to exceed :—

| | | |
|---|---|---|
| BAYONET FITTING | | |
| Normal | B 22 | 250 V |
| Small (single contact) | B 15s | 130 V |
| Small (double contact) | B 15d | 130 V |
| SCREW FITTING | | |
| Goliath | E 40 | 250 V |
| Medium | E 27 | 250 V |
| Small | E 14 | 250 V |
| Miniature | E 10 | 24 V |

Lamps are to be in accordance with the following :—

B 22 up to 200 W
E 27 up to 200 W
E 40 no limit

Lampholders are to be constructed of flame-retarding and non-hygroscopic material. All metal parts are to be of robust construction. Goliath lampholders are to be provided with means for locking the lamp in the holder. The temperature of cable connections is not to exceed the maximum conductor temperature permitted for the cable given in M 802.

Fluorescent Lighting

**1002** Fittings, reactors, capacitors and other auxiliaries are not to be mounted on surfaces which are subject to high temperatures. In ships for unrestricted service they are to be capable of operating at the ambient temperatures given in M 106.

Capacitors of 0·5 microfarads and above are to be provided with a means of prompt discharge on disconnection of the supply.

Inductors and high reactance transformers are to be installed as close as practicable to the associated discharge lamp.

**1003** Where cold cathode luminous discharge lamps of normal operating voltage above 250 V are used a warning notice calling attention to the voltage is to be displayed at points of access to the lamps and where otherwise necessary.

**1004** Emergency lighting is to be fitted in accordance with M 111.

## Section 11

### ACCESSORIES

Enclosures

**1101** Enclosures are to be of metal or of flame-retardant insulating materials.

Inspection and Draw Boxes

**1102** If metal conduit systems are used inspection and draw boxes are to be of metal and are to be in rigid electrical and mechanical connection with the conduits.

Socket Outlets and Plugs

**1103** Where it is necessary to earth the non-current-carrying parts of portable or transportable equipment an effective means of earthing is to be provided at the socket outlet.

On weather decks, galleys, laundries, machinery spaces and all wet situations, socket outlets and plugs are to be effectively shielded against rain or spray and are to be provided with means of maintaining this quality after removal of the plug.

The temperature rise on the live parts of socket outlets and plugs is not to exceed 30° C. Socket outlets and plugs are to be so constructed that they cannot be readily short circuited whether the plug is in or out, and so that a pin of the plug cannot be made to earth either pole of the socket outlet.

All socket outlets of current rating 15 A or more are to be provided with a switch.

## Section 12

### HEATING AND COOKING EQUIPMENT

**1201** Heaters are to be so constructed, installed and protected that clothing, bedding and other inflammable material cannot come in contact with them in such a manner as to cause risk of fire. There is to be no excessive heating of adjacent bulkheads or decks.

## Section 13

### BATTERIES

The following Rules apply to permanently installed secondary batteries.

#### Construction

**1301** The cells of all batteries are to be so constructed and secured as to prevent spilling of the electrolyte due to the motion of the ship and to prevent emission of acid or alkaline spray.

#### Location

**1302** Alkaline batteries and lead acid batteries are not to be installed in the same compartment.

Large batteries are to be installed in a space assigned to the batteries only or alternatively in a deck box if such a space is not available.

Engine starter batteries are to be located as close as practicable to the engine(s) served. If such batteries cannot be accommodated in the battery room they are to be installed so that adequate ventilation is ensured.

#### Lining of Compartments

**1303** Where acid is used as the electrolyte a tray of lead, or wood lined with lead is to be provided below the cells. Alternatively, the deck below the cells is to be protected with lead or other acid-resisting material so as effectually to prevent any acid from lodging in contact with the ship's structure.

The interiors of all battery compartments including shelves are to be painted with corrosion-resistant paint.

#### Equipment

**1304** Switches, fuses and other electrical equipment liable to cause an arc are not to be fitted in battery compartments.

#### Supports

**1305** Batteries are to be so arranged that each cell or crate of cells is accessible from the top and at least one side. Cells or crates are to be carried on non-absorbent insulating supports. Similar insulators are to be fitted to prevent any movement of cells arising from the motion of the ship.

#### Ventilation

**1306** Battery compartments are to be ventilated by an independent ventilating system.

Natural ventilation may be employed if ducts can be run directly from the top of the compartment to the open air with no part of the duct more than 45° from the vertical. If natural ventilation is impracticable mechanical ventilation is to be provided. Interior surfaces of ducts and fans are to be painted with corrosion-resistant paint. Fan motors are not to be located in the air stream.

All openings through the battery compartment bulkheads or decks, other than ventilation openings are to be effectively sealed to reduce the possibility of escape of gas from the battery compartment, into the ship.

Where practicable, battery lockers are to be ventilated similarly to battery compartments.

Deck boxes are to be adequately ventilated and means provided to prevent ingress of water.

#### Size of Batteries and Charging Facilities

**1307** Where batteries are used for starting main engines at least two batteries are to be fitted of such combined size that H 711 is complied with.

Adequate charging facilities are to be provided and where batteries are charged from line voltage, by means of a series resistor, protection against reversal of current is to be provided when the charging voltage is 20 per cent of line voltage or higher.

In d.c. systems means are to be provided to isolate the batteries from the low voltage system when being charged from a higher voltage system.

#### Protection

**1308** Batteries, except starter batteries, are to be protected against short circuit by a fuse in each insulated conductor or a multi-pole circuit-breaker at a position adjacent to the battery compartment.

**1309** A permanent notice is to be fitted to all battery compartments prohibiting naked lights and smoking.

## Section 14

### INTERNAL COMMUNICATIONS

**1401** Where a communication circuit takes its supply direct from power or lighting circuits and in other cases where the voltage of supply exceeds 50 V a.c. or 60 V d.c. all equipment is to be in accordance with the Rules for power and lighting circuits.

**1402** Cables are to be fitted in a similar manner to cables installed for lighting and power, but are to be segregated from the latter unless either the lighting and power cables or the communication cables are metal sheathed, or non-metallic impervious sheathed.

**1403** Communication circuits other than those supplied from primary batteries are to be protected against overload and short circuit.

#### Passenger Alarms

**1404** In all passenger ships, except those engaged on short international voyages, electrically operated alarms, for summoning passengers to muster stations are to be fitted. They are to be operable from the bridge.

#### Steering Gear

**1405** Means of communication are to be fitted to enable orders to be transmitted from the bridge to the alternative steering station required by D 2706.

## Section 15

### SEMI-CONDUCTOR RECTIFIERS FOR POWER

**1501** Rectifier stacks are to be so arranged that they may be removed from equipment without dismantling the complete unit.

**1502** Where forced cooling is provided the apparatus is to be so arranged that the rectifier cannot remain loaded unless effective cooling is maintained.

**1503** When necessary, means are to be provided to guard against d.c. voltage rise due to regenerated power.

**1504** When operated in parallel with other sources of d.c. power load sharing is to be such that under normal conditions overloading of any unit does not occur and the combination of paralleled equipment is stable.

**1505** Fungus protection of the mercury type is not to be used in the vicinity of selenium rectifiers.

**1506** Monocrystalline rectifiers such as germanium and silicon are to be capable of withstanding the effects of transient over-voltages coming from the ship's network.

## Section 16

### SPECIAL REQUIREMENTS FOR OIL TANKERS AND SHIPS INTENDED FOR THE CARRIAGE IN BULK OF LIQUID CARGOES HAVING A FLASH POINT OF 150° F. (65·5° C.) OR LESS

#### Generation and Distribution

**1601** The following generation and distribution systems only are to be used :—

Two-wire insulated for d.c. and single-phase a.c.

Three-wire insulated for three-phase a.c.

**1602** No current-carrying part of the distribution system is to be earthed other than through an earth indicating device or capacitors used for radio interference suppression.

#### Equipment in Dangerous Spaces

**1603** No electrical equipment or wiring, other than that certified intrinsically safe in respect of the gases and vapours involved (*see* M 109) is to be installed in any space where inflammable or explosive vapour may normally be expected to accumulate such as :—

Cargo oil tanks.

Cofferdams adjoining cargo oil tanks.

Cargo pump rooms.

Enclosed spaces immediately above cargo tank crowns (e.g., between decks).

Enclosed spaces, other than cofferdams, adjacent to, and below, the top of a cargo oil tank.

On open deck within 10 ft. (3 m.) of any oil tank outlet or vapour outlet.

except as detailed in 1604 to 1609.

**1604** In enclosed spaces immediately above cargo tank crowns lighting fittings only are to be installed and they are to be of flameproof type. The switches controlling such fittings are to be double-pole and are to be located in a safe place. Through runs of cable are permitted.

**1605** Electrical equipment additional to the lighting fittings referred to in 1604 above may be installed in between deck spaces immediately above cargo tank crowns provided that :—

(*a*) Such equipment is housed in a suitably ventilated compartment having access solely from the deck above, and of which the floor is separated from the cargo oil tanks by a cofferdam, and the boundaries are gas tight with respect to the cofferdam and the between deck space.

(*b*) Cables are supported clear of the gas tight boundaries of the compartment. Plans showing the construction of the compartment, the electrical apparatus to be housed therein and the provisions for ventilation are to be submitted.

**1606** In positions on open deck and within a distance of 10 ft. (3 m.) from cargo tank hatches, sight ports, tank cleaning openings, ullage openings, sounding pipes, cargo vapour outlets or ventilators, or cargo pump room entrances electrical equipment is to be flameproof.

**1607** Hull fittings containing the oscillators of electric sounding devices may be installed in a cofferdam or cargo pump room forward of the oil tanks provided that :—

(*a*) Such fittings are housed in a gas tight enclosure clear of the cargo tank bulkhead.

(*b*) The cables to the oscillators are run within the space in heavy gauge galvanized steel pipe with bolted flange joints and led through watertight glands fitted at the external extremity of the pipe.

**1608** Cargo pump rooms may be lit by one or both of the following methods :—

(*a*) By flameproof fittings within the compartment. The lamps are to be arranged on at least two independent circuits controlled by fuses and double-pole switches located in a safe space outside the compartment. The lamps and corresponding switches and fuses are to be suitably labelled for identification purposes. Well glasses and other covers are to be secured by screws or nuts requiring a special key for their removal. The cables are to comply with 1613, protected from mechanical damage and supported clear of bulkheads and deckheads.

(*b*) By fittings located in a safe space. Where a safe space is immediately adjacent the cargo pump rooms may be lighted either :—

(i) From that safe space through gas tight and watertight glazed ports permanently fitted in the bulkhead or deckhead.

(ii) Or by lighting fittings which are flameproof relative to the cargo pump room and gas tight relative to the safe space and so designed to admit replacement of the lamp from the safe space.

**1609** Enclosed spaces other than cofferdams adjacent to and below the top of a cargo tank may be lighted in the same manner as cargo pump rooms. The provisions for ventilation are to be submitted for approval. (*See* D 4012.)

### Portable Lamps

**1610** Portable lamps other than self-contained battery fed or equivalent lamps of a certified type, in respect of the gases and vapours involved, are not to be used in any dangerous space.

### Lighting Fittings

**1611** Except in accommodation spaces enclosing cases of lighting fittings are to be of metal or equally durable and non-inflammable approved material.

### Fuses

**1612** Only cartridge-type fuses are to be used.

### Cables on Fore and Aft Gangways and in Dangerous Spaces

**1613** Cables on fore and aft gangways and in dangerous spaces, where permitted, are to be sheathed with one of the following :—

(i) Copper sheath (for mineral insulated cable).

(ii) Lead sheath plus further mechanical protection, e.g. armour or non-metallic impervious sheath.

(iii) Non-metallic impervious sheath plus armour.

Aluminium armour is not to be used. Where corrosion may be expected non-metallic impervious sheath, or equivalent protection, is to be applied over steel armour for corrosion protection.

**1614** Cables installed on deck in way of cargo tanks or on fore and aft gangways are to be protected against mechanical damage. Where pipes are used the total cross-sectional area of the cables contained

within a pipe is not to be more than 30 per cent of the internal cross-sectional area of the pipe. Glands are to be fitted at each bulkhead through which the pipes pass, to allow for expansion and the working of the ship. The pipe system is to be drained and ventilated.

**1615** All cables except mineral-insulated copper sheathed cables installed on deck in way of cargo tanks, or on fore and aft gangways and all pipes containing such cables are to be kept throughout their length at such distance from steam and exhaust pipes as to be substantially free from any heating effect from such pipes. At the bulkhead this distance is to be not less than 18 in. (450 mm.) from the flanges of steam pipes more than 3 in. (75 mm.) in diameter, and not less than 12 in. (300 mm.) from the flanges of steam pipes 3 in. (75 mm.) or less in diameter.

### Flameproof Equipment

**1616** Where flameproof equipment is required, effective means of complete isolation located in a safe space is to be provided. Effective provision is to be made to prevent unauthorised operation resulting in restoration of supply while the risk of exposing live conductors exists.

### Intrinsically Safe Equipment

**1617** Where intrinsically safe equipment is installed the wiring of the circuit is to be physically separated from that of other circuits. Intrinsically safe equipment may be used where flameproof equipment is required by the Rules.

## Section 17

## ELECTRIC PROPELLING MACHINERY

### General

**1701** All electric propelling machinery including switchgear, control gear, cables, main and auxiliary generators, motors and exciters is to comply with the relevant sections of the Rules and is to be constructed under special survey.

**1702** Prime movers are to comply with the relevant sections of Chapter H.

**1703** Armature shafts and other important steel forgings and castings are to comply with the requirements of Chapter P.

**1704** The torsional vibration characteristics of the propulsion system are to be submitted as required by H 302 or H 602 whichever is applicable.

**1705** Cooling water and lubricating oil systems are to comply with E 8 and E 9 where applicable.

### General Arrangements

**1706** Where the arrangements permit a propulsion motor to be connected to generating plant having a continuous rating greater than the motor rating, means are to be provided to limit the continuous input to the motor to a value not exceeding the continuous full load torque for which the motor and shafts are approved.

**1707** Motors of 500 h.p. or over and generators of 400 kW or over are to be provided with means for heating the windings to prevent condensation when idle. If steam pipes are used for this purpose the joints are not to be within the machine.

### Excitation

**1708** Systems dependent on the auxiliary generators for excitation are to be capable of manœuvring and of maintaining power at all times with a fall of 10 per cent excitation voltage at the busbars.

Where motor driven exciters, boosters, balancers or rectifiers are provided for excitation purposes, provision for an alternative supply of excitation is to be made. Where two machines are used each of at least 50 per cent of the required power it will be sufficient to provide one spare machine.

**1709** Negative boosters are to be provided with overspeed protection, where necessary.

**1710** In d.c. constant pressure systems arrangements for generator and motor excitation are to be such that if the motor excitation circuit is opened by a switch or contactor the generator excitation is simultaneously interrupted or the generator voltage is immediately reduced to zero.

**1711** Voltages—No voltage limitations are specified.

### Manœuvring Controls

**1712** When two or more control stations are provided indicating lights are to be located at each control to indicate which station is in control.

**1713** Where bridge or deck control is employed alternative control in the engine room is to be provided.

**1714** Suitable interlocks, operating preferably by mechanical means are to be provided to prevent damage to the plant as a result of incorrect switching, such as the opening of switches or contactors not intended to be operated while carrying current.

**1715** Provision is to be made for the manual operation without undue manual effort, of all manœuvring contactors, switches, field regulators and controllers. Where electric, pneumatic or hydraulic aid is used for normal operation, failure of such aid is not to result in interruption of power to the propeller shaft and any such device is to be capable of purely manual operation without delay. This latter requirement does not apply to bridge control equipment.

Alternative arrangements will be specially considered.

### Cables

**1716** Conductors in circuits essential for manœuvring or maintenance of propelling power are to be stranded having not less than seven strands and shall have a nominal cross sectional area of not less than 0·0045 sq. in. or 2,5 sq. mm.

**1717** Cables which are connected to the slip rings of synchronous motors are to be suitably insulated for the voltage to which they are subjected during manœuvring.

**1718** All joints are to be so made as to inhibit corrosion. They are to be arranged and supported in a manner suitable for withstanding the electro-mechanical forces due to short-circuit.

### Overload and Short-Circuit Protection

**1719** Provision is to be made for protection against severe overloads, and electrical faults likely to result in damage to the plant.

### Earth Leakage Detection

**1720** The main propulsion circuit is to be provided with means for detecting earth faults. For direct-current equipments exceeding 500 V and for all alternating-current equipments, aural and visual alarms are to be automatically operated on the occurrence of an earth fault, but the operation of such devices is not to interrupt the power supply. A switch may be provided to switch off the aural device, but in such cases the visual alarm shall remain switched on to indicate that the aural device is switched off. Alternative arrangements will be specially considered. If an earth connection is used for operating the detector arrangements then in direct-current systems the earth circuit is to be automatically opened in order to stop the circulation of fault current. In alternating-current systems the fault current is to be interrupted or limited to a safe value.

**1721** Earth leakage devices are to be arranged to function for all earth faults exceeding 5 amp. In three-phase star connected alternating-current generators and motors with neutral points earthed, the earth leakage device shall operate on the occurrence of an earth fault in the windings of the machine, subject to the provision that 5 per cent of the coils at the neutral end of each phase may be left unprotected by the device. In high voltage a.c. systems where the capacitive leakage current is high consideration will be given to increasing this figure of 5 per cent.

**1722** Excitation circuits are to be provided with lamps, voltmeters or other means to indicate continuously the state of the insulation of the excitation circuits under running conditions.

### Discharge Protection

**1723** For the protection of field windings and cables, means are to be provided for limiting the induced voltage when the field circuits are opened, or alternatively the induced voltage, when the field circuits are opened, is to be taken at the nominal design voltage.

**1724** Where excitation is obtained from the auxiliary busbars means are to be provided to limit the voltage induced at the busbars when the auxiliary circuit-breaker or the distribution circuit-breaker opens.

**1725** Shunt resistors which are connected across the field circuit of synchronous propulsion motors when they are functioning as asynchronous motors are to be suitably insulated for the voltage induced when reversing and are to be amply rated to allow for inadvertent delay during the reversing operation.

### Safety Devices

**1726** Where separately driven direct-current generators are connected electrically in series means are to be provided to prevent reversal of the direction of rotation of any of them on the failure of the prime mover.

**1727** Where, on stopping or reversing the propeller, the regenerated energy transmitted by the propulsion motor is such as to cause a dangerous increase of speed in the prime mover means are to be provided for suitably absorbing or limiting such energy.

**1728** Contactors and switches used for reversing the rotation of the propulsion motors are to be provided with means for forcibly opening them if they should inadvertently remain closed and they are to be so interlocked as to prevent the circuits for ahead and astern being closed simultaneously.

### Alarms

**1729** An aural alarm device is to be provided for machines having enclosed ventilating systems, arranged to operate in the event of the temperature of the heated air exceeding the predetermined safe value.

### Identification

**1730** All important circuits, instruments and apparatus are to be clearly labelled for identification.

## Section 18

## LIGHTNING CONDUCTORS

### General

**1801** Lightning conductors are to be fitted to each mast of all wood, composite, and steel ships having wooden masts or topmasts. They need not be fitted to steel ships having steel masts.

### Construction

**1802** In wood and composite ships fitted with wooden masts, the lightning conductors are to be composed of continuous copper tape and/or rope, having a section not less than 0·15 square inch (100 sq. mm.) which are to be riveted with copper rivets or fastened with copper clamps to a suitable copper spike not less than 0·5 inch (13 mm.) in diameter, projecting at least 6 inches (150 mm.) above the top of the mast. Where tape is used the lower end of the tape is to terminate at the point at which the shrouds leave the mast, and is to be securely clamped to a copper rope of not less than 0·5 inch (13 mm.) diameter. This copper rope is to be led down the shrouds and is to be securely clamped to a copper plate not less than 2 square feet (0,2 sq. m.) in area, fixed well below the light waterline and attached to the ship's side in such a manner that it is to be immersed under all conditions of heel.

**1803** In wood and composite ships fitted with steel masts, each mast is to be connected to a copper plate in accordance with 1802, the copper rope being securely attached to and in good electrical contact with the mast at or above the point at which the shrouds leave the mast.

**1804** In steel ships fitted with wooden masts, the lightning conductors are to be composed of copper tape or rope terminating in a spike, as set forth in 1802. At the lower end this copper tape or rope is to be securely clamped to the nearest metal forming part of the hull of the ship.

**1805** Lightning conductors are to be run as straight as possible, and sharp bends in the conductors are to be avoided. All clamps used are to be of brass or copper, preferably of the serrated contact type, and efficiently locked. No connection is to be dependent on a soldered joint.

**1806** The resistance of the lightning conductor, measured between the mast head and the position on the earth plate or hull to which the lightning conductor is earthed, is not to exceed 0,02 ohms.

## Section 19

## TRIALS

### General

**1901** Before a new installation, or any alteration or addition to an existing installation is put into service the following trials are to be carried out. These trials are in addition to any acceptance tests which may have been carried out at the manufacturers' works.

### Insulation Resistance

**1902** Instruments—Insulation resistance is to be measured using a self-contained instrument such as a direct reading ohmmeter of the generator type applying a voltage of at least 500 V.

Where a circuit incorporates capacitors of more than two microfarads total capacitance, a constant-voltage type instrument is to be used to ensure accurate test readings.

(*a*) Power and Lighting Circuits—The insulation resistance between all insulated poles and earth and, where practicable, between poles is to be at least 1 megohm.

The installation may be sub-divided and appliances may be disconnected if initial tests produce results less than this figure.

(*b*) INTERNAL COMMUNICATION CIRCUITS—Circuits operating at 50 V and above are to have an insulation resistance between conductors and between each conductor and earth of at least 1 megohm.

Circuits operating at less than 50 V are to have an insulation resistance of at least 0,33 megohm.

(*c*) SWITCHBOARDS, SECTION BOARDS AND DISTRIBUTION BOARDS—The insulation resistance is to be at least 1 megohm when measured between each busbar and earth and between busbars. This test may be made with all circuit-breakers and switches open and all fuse links for pilot lamps, earth fault-indicating lamps, volt-meters, etc., removed and voltage coils temporarily disconnected, where otherwise damage may result.

(*d*) GENERATORS AND MOTORS—The insulation resistance of generators and motors, in normal working condition and with all parts in place is to be measured and recorded.

The test should be carried out with the machine hot, if possible. The insulation resistance of generator and motor cables, field windings and control gear is to be at least 1 megohm.

### Earth Continuity

**1903** Tests are to be made to verify that all earth continuity conductors are effective and that the bonding and earthing of metallic conduit and/or sheathing of cables is effective.

### Performance

**1904** It is to be demonstrated that the Rules have been complied with in respect of :—

Satisfactory commutation and performance of each generator throughout a run at full rated load.

Temperatures of joints, connections, circuit-breakers and fuses.

The operation of engine governors, synchronizing devices, overspeed trips, reverse-current, reverse-power and over-current trips and other safety devices.

Voltage regulation of every generator when full rated load is suddenly thrown off.

For a.c. and d.c. generators, satisfactory parallel operation and kW load sharing of all generators capable of being operated in parallel at all loads up to normal sea or harbour working load. For a.c. generators satisfactory parallel operation and kVA load sharing of all generators capable of being operated in parallel at all loads up to normal sea or harbour working load.

All essential motors and other important equipment are to be operated under service conditions, though not necessarily at full load or simultaneously for a sufficient length of time to demonstrate that they are satisfactory.

Propulsion equipment is to be tested under working conditions and operated in the presence of the Surveyors and to their satisfaction. The equipment is to have sufficient power for going astern to secure proper control of the ship in all normal circumstances. In passenger ships the ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, under normal manœuvring conditions, and so bring the ship to rest from maximum ahead service speed is to be demonstrated at the sea trial.

### Voltage Drop

**1905** Voltage drop is to be measured, where necessary, to verify that this is not excessive. (*See* M 813.)

## Section 20 1965.

### SPARE GEAR

**2001** For the efficient operation of the ship the articles of spare gear mentioned in the following paragraphs, so far as they are applicable, should be supplied. Owners should arrange to replace or make good used items as opportunity occurs.

**2002** One set of brushes and one set of bearings for one machine for each size of generator and for each size of motor engaged on essential services, such as those indicated below :—

Air compressors for heavy oil engines.
Scavenge blowers.
Air pumps.
Ballast pumps.
Bilge pumps.
Circulating and cooling water pumps.
Condenser circulating pumps.
Extraction pumps.
Feed water pumps.

Fire pumps.

Fuel valve cooling pumps.

Lubricating oil pumps.

Oil fuel pumps and oil fuel burning units.

Cargo refrigerating motors, including compressors, brine pump, circulating pump, fans, etc.

Fans for forced draught to boilers.

Steering gear.

Windlasses.

Ventilating fans for engine room and boiler rooms.

Oil separators.

### Steering Gear

**2003** For each size of steering gear motor and motor-generator if no standby electrical machine is installed, the following spare gear is required in addition to the spares for motors enumerated above :—

(i) Direct-current machinery :—

1 spare armature of each size fitted complete with shaft and half coupling.

1 spare field coil of each type fitted.

(ii) Alternating-current machinery :—

1 spare stator complete of each size fitted.

### Fans for Refrigerating Equipment

**2004** For electrically-driven air circulating fans the following spare gear will be required, in addition to the spares enumerated in 2002 for each size of motor installed, except where a duplicate fan motor in accordance with N 370 is installed :—

1 motor complete, or

Direct-current machinery :—

1 armature complete.

1 complete set of field coils.

1 complete set of brush gear.

1 set of bearings.

Alternating-current machinery :—

1 stator complete.

1 set of bearings.

### Control Gear

**2005** For the starting gear of motors, such as those enumerated in 2002 :—

1 set of contacts which are subject to burning or wear.

1 set of springs.

10 per cent of each different resistance element, but at least one of each.

1 of each type of shunt coil used for contactors, relays or low voltage release.

For six or less starters in which these parts are interchangeable it will be sufficient to provide one set of spares for the starter employing the greatest number of parts.

### Switchgear and Distribution Boards

**2006** For each type of circuit-breaker on each pole :—

1 set of contacts which are subject to burning or wear.

1 set of parts subject to wear.

1 set of springs.

1 shunt trip coil and 1 resistance element, of each kind used.

15 per cent but not less than six of each type of cartridge or other non-renewable fuses.

Rewireable fuse-handles; 5 per cent, with a minimum of one, of each size or type used, provided that not more than 12 need be supplied.

### Navigating and Signal Lights

**2007** Navigating and signal lights and their pilot lamps for indicating devices :—

1 complete spare set of lamps.

### Emergency Lighting

**2008** Where supplied from storage batteries of a voltage different from the ship's circuit :—

1 complete spare set of lamps.

### Electric Couplings

**2009** For each size of electric coupling used for propulsion purposes, the following is required as a minimum :—

1 complete set of brush gear.

1 field coil of each type fitted.

1 set of brushes for one coupling.

1 gauge for checking the magnetic air gap.

Spares for the control gear and switchgear as above.

**Propulsion Equipment**

**2010** Owing to the varied characteristics of equipments an exact list of spares cannot be specified but the following should be provided as a minimum :—

(*a*) Generators, Motors and Exciters—One set of bearing bushes, with oil rings, if used, of each size and type for the propulsion generators, motor and exciter.

Two lines of brush holders of each size and type.

One set of carbon brushes for one generator, exciter, and one motor.

One shunt field coil of each size and kind used for direct-current generators, exciter and motors.

One set of slip rings for one motor if of the alternating-current type.

(*b*) Switch and Control Gear

One set of contacts liable to burning or wear.

One set of springs.

10 per cent of each different resistance element, but at least one of each.

One of each type of shunt wound coil used for contactors, relays, or trip coils.

Two fuse handles of each type and size, or 15 per cent, but not less than six of each type of fuse.

*November, 1964*

# RECOMMENDATIONS FOR ELECTRICAL EQUIPMENT

The following recommendations are for those features of the electrical installation which are not considered to be the concern of classification and therefore are not included in Chapter M. It should be clearly understood that these recommendations are not mandatory and are intended merely for the use of those Shipowners and Shipbuilders who may seek more guidance on equipment standards than is given in the Rules.

# RECOMMENDATIONS FOR ELECTRICAL EQUIPMENT

## Section 1

### GENERAL

**Earthing**

Rule 108 The following items do not require to be earthed :—

(i) Lamp caps.

(ii) Shades, reflectors and guards supported on lighting fittings constructed of or shrouded in insulating material.

(iii) Metal parts or screws in, or through, insulating material which are thereby separated from current carrying parts in such a way that they cannot become live or come into contact with earthed parts.

(iv) Portable appliances having double insulation.

(v) Bearing housings which are insulated in order to prevent circulation of current in the bearings.

(vi) Clips for fluorescent lamps.

(vii) Cable clips.

(viii) Apparatus supplied at extra low voltage.

(ix) Fixed apparatus or parts of apparatus which, although not shrouded in insulating material is so guarded that it cannot be touched and cannot come in contact with exposed metal.

## Section 2

### SYSTEMS OF SUPPLY

It is recommended that in alternating current systems for socket outlets where special precautions against shock are necessary, e.g., portable boiler cleaning tools where the operator works in a confined space and his skin will be damp, the following maximum voltages should be used :—

| | |
|---|---|
| (i) Supplied direct | 55V |
| (ii) Where a safety isolating transformer is used supplying only one socket outlet | 250V |

## Section 4

### ROTATING MACHINERY

With the exception of machines for purely domestic purposes such as motors of vacuum cleaners, portable tools and galley equipment it is recommended that all machines comply with the requirements of M 4. Machines for domestic purposes should comply with a national or international standard.

**Short Circuit**

Sudden short circuit tests, when required by the purchaser, should be a matter for agreement between purchaser and manufacturer. If carried out they should be made at an initial terminal voltage not greater than the rated voltage of the machine and at rated frequency.

**Field Regulation of Direct Current Generators**

Rule M 418 This requirement will be met if at the conclusion of the full load temperature test, with full load current and normal full load voltage at the terminals when running at full load engine speed, the voltage across the shunt field regulator, with an ambient air temperature of 15° C., is not less than 14 per cent of the terminal voltage of the machine. This makes allowance for the difference in field resistance between average test conditions and the most severe service conditions.

**Transient Voltage Response of Alternating Current Service Generators**

Rule M 424 To meet this requirement it is recommended that one of the following alternatives be applied as determined by the characteristics of the installation, but such a test should not be required if evidence can be produced that a test has been carried out on a similar machine.

*(a) When the starting kVA of the motors is 35 per cent or less of the capacity of the generating plant and where a rapid voltage recovery is not required.*

With the generator driven at its rated speed at no load and giving its rated voltage under the control of the AVR, the maximum voltage change should not

exceed 15 per cent when a current equal to 35 per cent full load current at any power factor between zero and 0,4 lagging is suddenly drawn. The voltage should be restored to within 3 per cent of rated voltage in not more than 1,5 seconds.

(*b*) *When the starting kVA of the largest motor or group of motors liable to be started simultaneously exceeds 35 per cent but is less than 60 per cent of the capacity of the generating plant.*

With the generator driven at its rated speed at no load and giving its rated voltage under the control of the AVR the maximum voltage change should not exceed 15 per cent when a current equal to 60 per cent full load current at any power factor between zero and 0,4 lagging is suddenly drawn. The voltage should be restored to within 3 per cent of the rated voltage in not more than one second.

(*c*) *When the starting kVA of the largest motor or group of motors liable to be started simultaneously exceeds 60 per cent of the capacity of the generating plant, or when the recovery time of one second is not satisfactory for the operation of special devices supplied by the same generating plant.*

A specification of the performance of the generating plant should be agreed between purchaser and manufacturer.

### Wattless Load Sharing

Rule M 426 This requirement may be otherwise stated:—

"When alternating current generators are operated in parallel the wattless loads of the individual generating sets should not differ from their proportionate share of the total wattless load by more than 10 per cent of the rated wattless output of the largest machine."

M 426 gives a more convenient method of measuring wattless load sharing but other methods can be used, e.g., measurement of power factor.

### Frequency

When running alternating current motors from a shore supply of lower frequency care should be taken to lower the terminal voltage at the motors in proportion to frequency in order not to overload the motors.

## Section 5

### DISTRIBUTION

It is recommended that in machinery spaces, large galleys and such spaces as corridors, stairways leading to boat decks and public rooms, lighting should be supplied from at least two final sub-circuits one of which could be the emergency circuit so that failure of one circuit does not reduce the lighting to an inadequate level.

### Steering Gear

Where electric power is used for the operation of steering gear it is recommended that failure of supply be indicated by audible and visual alarms in the engine room and/or pilot house.

In any steering gear where electric control only is used it is recommended that the control be duplicated.

## Section 6

### SWITCHBOARDS, SWITCHGEAR AND PROTECTIVE EQUIPMENT

All main and emergency switchboards should be provided with handrails in front of the panel. Where the switchboard is of the open type the rail should be non-conducting. The platform in front of and behind switchboards should have a non-slip surface.

Where necessary insulated handrails should be fitted behind switchboards and passageways behind switchboards should be provided with access doors at each end, these to be capable of being opened from the passageway. The doors should bear a prominent and permanent notice giving the maximum voltage.

For voltages between poles or to earth exceeding 250V direct current or 55V alternating current, switchboards should be of the dead front type. Where the voltage exceeds 55V during operation an insulating mat should be provided.

Where an earth indicating system using either two or three lamps is used the lamps should be of metal filament type each not exceeding 30W. They should be of the same colour and placed not more than 6 in. apart.

For preference tripping systems the following overcurrent settings are recommended (expressed as a percentage of the rated current of the generator or circuit to be protected).

| | |
|---|---|
| Main generator circuit breaker | 150 per cent |
| Preference tripping relays | 110 per cent |

Time delays should be established in accordance with the nature of the load the following values being given as an example :—

| | |
|---|---|
| First tripping circuit breaker | 5 sec. |
| Second tripping circuit breaker | 10 sec. |
| Third tripping circuit breaker | 15 sec. |
| Main generator circuit breaker | 20 sec. |

For overloads less than 10 per cent protection may consist of an alarm signal operated by a time delayed relay set to approximately 110 per cent rated current of the generator.

Two-wire circuits of rating exceeding 100A should be controlled as a minimum in one insulated pole or phase by a switch. Three-wire alternating current circuits rated at more than 60A should be controlled by a triple-pole linked switch.

The minimum operating current of every circuit breaker should be not greater than twice the rating of the smallest conductor which it is installed to protect except for motor circuits where short circuit protection only is required (in these cases three times the cable rating).

The overcurrent setting of a circuit breaker will depend on individual arrangements and in motor circuits must be matched to the load temperature characteristics of the motor, the following figures being given merely as an example :—

| | Overcurrent |
|---|---|
| Continuously rated circuits | 25 per cent |
| Intermittently rated circuits | 50 per cent |
| Steering gear and emergency circuits | 200 per cent |

Circuit breakers, contactors and switches should be so installed that, as far as practicable, their moving parts and associated relays are not live when the circuit breaker or contactor is in the OFF position.

Circuit breakers and contactors should be provided with a means of isolation.

In large installations, where fault levels are high, circuit breakers should be of the power operated type.

In earthed systems of large capacity, protection against internal faults in the generators should be considered.

All generators arranged for parallel operation with one another or with the shore power feeder should be provided with undervoltage release which prevents the closing of the appropriate circuit breaker until the generator terminal voltage reaches at least 70 per cent of the rated voltage.

The installation of automatic circuit opening devices, other than for short circuit protection, is not recommended in exciter circuits.

In alternating current systems consideration should be given to the fitting of an automatic trip to main generator circuit breakers which will open the breaker on loss of excitation.

The fitting of an ammeter in exciter circuits is recommended.

### Selection of Fuses

(i) Fuses for steady load circuits, such as heating circuits, should be of current rating at least equal to that of the apparatus. If other overcurrent protection is provided or if discrimination requires it, a fuse of greater current rating may be necessary.

(ii) Fuses for fluctuating load circuits, such as motor circuits, transformer circuits, lighting circuits and capacitor circuits, should have a time/current characteristic which allows the transient overcurrent to be carried without operation of the fuse. It will sometimes be necessary to select fuses of a current rating greater than that of the circuit.

For motor circuits it will be necessary to obtain particulars of the magnitude and duration of the starting current and to select fuses by referring to the time/current characteristics.

## Section 8

### CABLES

In large installations where short circuit currents may be high it is recommended that cables are armoured and in three-phase installations, as far as is practicable three-core cables carrying the three-phase currents should be employed.

Where these precautions are necessary particular care should be taken with the cable supports especially at the ends of cables.

In 110V installations where lighting cables may be fully loaded, are bunched together and are installed between wooden panelling or similar locations it is recommended that the minimum size of conductor be not less than ·003 sq. in. (2,5 sq. mm.).

## Section 10

### LIGHTING

In bathrooms, galleys, laundries and similar places the parts of a lampholder likely to be touched should be constructed of or shrouded in insulating material and fitted with a protective shield or totally enclosed fittings should be used.

Lighting switches for bathrooms and similar locations should be outside such spaces unless they are of construction suitable for humid conditions.

Lamps which are used near combustible material should be installed in totally enclosed fittings.

Where tubular fluorescent lighting is used, lighting by one or more filament lamps should be provided, especially in compartments containing running machinery.

Lamps which are used in spaces liable to contain explosive or inflammable materials should be installed in flameproof fittings.

Filament lamps are recommended for emergency lighting.

Live parts of fluorescent lighting installations should be screened with earthed metal or insulating material.

#### Connections to Lighting Fittings

Due to the reduced physical sizes of lamps in many countries, e.g., 100W lamps can now be installed in many fittings that previously were designed for 60W lamps care must be taken with cable connections so that the maximum conductor temperature is not exceeded. Tests carried out in the past have shown a temperature rise at some lampholder terminals of 80° C. and a distance about 0·625 in. (16 mm.) from the lampholder terminals exhibited a temperature rise of 60° C.

Where cables operate at temperatures in excess of the permitted maximum, deterioration of the insulation occurs with premature failure in service.

Comments on the behaviour of the various classes of insulation are given below :—

(*a*) Rubber

Maximum conductor temperature 60° C. At higher temperatures it ages with increasing severity, reducing its life.

(*b*) Polyvinyl Chloride

Maximum conductor temperature 60° C. At higher temperatures it may flow away from the conductor when under pressure, e.g., clips.

(*c*) Polychloroprene

This is usually associated with rubber when maximum conductor temperature is 60° C. At higher temperatures it absorbs moisture after cooling leading to electrical breakdown.

(*d*) Butyl

Maximum conductor temperature 80° C. At 130° C. it ages rapidly and may turn into a powder which can fall away from the conductor if subject to vibration or shock.

(*e*) Silicone Rubber

Maximum conductor temperature 150° C. and intermittently up to 200° C.

Fittings should be designed so that the maximum permitted temperature for the cable is not exceeded. Alternatively high temperature tails (e.g., silicone rubber) should be incorporated in the fitting and led to a terminal block.

## Section 11

### ACCESSORIES

Where differing distribution systems are used any socket outlets and plugs should be of such design that incorrect connection cannot be made.

In general socket outlets should not be fitted in bathrooms, lavatories and similar wet places.

In systems at 110V direct current and above or 55V alternating current and above socket outlets and plugs should be provided with an earthing contact. This contact should make contact before the live pins when the plug is inserted.

#### Heating and Cooking Equipment

Electric heating and cooking equipment should be so constructed that parts which must be handled cannot exceed 55° C.

Heating elements should be readily replaceable.

Connections between elements, switches and supply cables should be carried out with terminals.

Connections between elements and between elements and terminals to which insulated cables may be connected, unless self-supporting and rigidly secured in position should be continuously insulated with incombustible material.

Heating elements should be suitably guarded. Live parts of cooking appliances should be protected so that cooking utensils cannot come into contact with them.

Space heaters in cabins, lockers, etc., should be of the convector type. Space heaters should not be installed in spaces where inflammable gases might accumulate.

### Batteries

Batteries should be located where they are not exposed to excessive heat or extreme cold. Batteries for emergency service, including emergency diesel engine starting should be located above the bulkhead deck. The best operating conditions for batteries are obtained when the working temperature is between 15° C. and 27° C. Where practicable the temperature of the electrolyte should not be permitted to exceed 50° C. since higher temperatures tend to reduce the life of the battery. Low temperatures may temporarily reduce the capacity of the battery.

Mechanical ventilation of battery rooms should be capable of changing the air in the battery room four or five times per hour.

### Spare Gear

The provision of an insulation tester is recommended.

## Section 16

## SPECIAL REQUIREMENTS FOR OIL TANKERS

### Flameproof and Intrinsically Safe Equipment

It is sometimes stated that flameproof equipment should be permitted in dangerous spaces, e.g., cargo pump rooms, but this cannot be agreed except as stated in Section 16. Flameproof equipment is flameproof when it leaves the manufacturers' works and after a period of service may no longer be flameproof, due to faulty or inadequate maintenance.

Flameproof lighting fittings are permitted in pump rooms, only because many pump rooms are so large that they cannot be adequately lit through glazed ports.

Intrinsically safe equipment and the circuit to which it belongs is to be physically separated from all other circuits. This is because the certificate of intrinsic safety involves both the equipment and its circuit.

# Chapter N

# REFRIGERATED CARGO INSTALLATIONS

Extract from Chapter B for reference

**B 901** On application from Owners, refrigerated cargo installations which comply with Chapter N of the Rules and are favourably reported on by the Surveyors will be assigned an appropriate class in accordance with N 1. Certificates will be issued and the class notation, together with the particulars of the installation, will be entered in the Supplement.

**B 902** The class assigned will be retained provided the installation is found to be in a good and efficient condition at the Periodical, Loading Port, and other Surveys set forth in N 8.

## Section 1

### GENERAL

**Class Notation**

**101** The class notation assigned will be Lloyd's RMC followed by the minimum temperature(s) approved by the Committee for the installation with the maximum sea temperature stated, e.g. "to maintain temp. 10° F. in the lower and 31° F. in the upper chamber with sea temperature 85° F. maximum."

NOTE.—The temperature at which the cargo is to be carried is not the responsibility of the Society.

**102** Installations constructed under the Society's Special Survey in accordance with N 2 to N 6 will be eligible for the distinguishing mark ✠ before the class notation, thus ✠Lloyd's RMC. In other cases the mark ✠ will not be assigned.

**103** In the case of installations designed to reduce the temperature of non-precooled cargoes a mark ‡ will be shown under the class notation in the Appendix to the Register Book and will be included on the certificate as an indication that an installation has been considered by the Society for this duty. A special statement showing the cargo cooling capabilities of such installations, in respect of stated weights and descriptions of cargoes under stated conditions, will be issued on application by the Owners to the Society's Head Office.

**Special Cases**

**104** The Committee will be prepared to give consideration to cases of ships engaged on voyages of short duration, to installations of small capacity, or to other special circumstances. In such cases the class may include a service limitation or other restriction.

**Refrigerants**

**105** These Rules are applicable to the following primary refrigerants:—

Carbon Dioxide
Ammonia
Dichlorodifluoromethane
Monochlorodifluoromethane

Proposals to use other refrigerants will be specially considered on application, but methyl chloride will not be accepted.

## NEW INSTALLATIONS

## Section 2

### SPECIAL SURVEY DURING CONSTRUCTION

**201** New installations intended for classification are to be constructed under the Society's Special Survey in accordance with the requirements of N 3 and N 4; tests are to be carried out as specified in N 5, and spare gear is to be supplied as listed in N 6.

**Information and Plans to be Submitted**

**202** The following information and plans are to be forwarded for consideration before construction is commenced :—

(*a*) Refrigerating plant—standard data sheet in duplicate. (Copies of this data sheet may be obtained from the Society's local office.)

(*b*) Refrigerating plant—detailed specification in triplicate.

(*c*) Insulation—detailed specification in triplicate.

(*d*) General arrangement of insulated chambers in elevation and plan. The plans are to be to a scale of not less than 1:50 and adequate for the measurement of the external

surfaces and the deck and bulkhead edges. Dimensions and spacing of frames, beams and stiffeners and details of other steel work protruding into the insulation and within the chambers are to be shown. Oil fuel and liquid cargo tanks adjacent to or below the chambers are to be indicated, and whether heating is provided for such tanks. Ventilating and air conditioning trunks and ducts passing through chambers are to be shown. The plans should include a diagram showing the position of the chambers in relation to other parts of the ship if this is not otherwise apparent.

(*e*) Detailed plans showing the thickness and methods of attachment of the insulation and linings on all surfaces, including girders, hatch coamings and pillars; details of insulated doors, and hatch, access, bilge and manhole plugs and their frames. Method of attachment of brine or direct expansion grids and meat rails are also to be shown.

(*f*) Arrangement of air ducts (including method of cooling spaces within hatch coamings), air coolers, fans and their motors.

(*g*) Air cooler defrosting arrangements, other than hot brine circulating systems.

(*h*) Arrangement of brine grids including those in way of hatches; and method of construction.

(*i*) Arrangement of chamber thermometers.

(*j*) General arrangement of refrigerating machinery.

(*k*) Brine circuit diagram with particulars of piping.

(*l*) Primary refrigerant gas and liquid circuit diagrams and full particulars of all pressure piping.

(*m*) Sectional arrangement of refrigerant compressors.

Detailed dimensioned plans of :—

(*n*) Compressor crank shafts.

(*o*) Compressor crank cases where exposed to the refrigerant pressure.

(*p*) Condensers.

(*q*) Evaporators (brine coolers).

(*r*) Air coolers.

(*s*) Oil separators.

(*t*) Liquid receivers.

(*u*) All other pressure vessels.

NOTE.—All the plans listed, and any others which may be specially requested are to be forwarded in triplicate.

(*v*) Similar plans are required for refrigerating plant of other designs.

(*w*) Where the refrigerating machines are driven by oil engines particulars and plans are to be submitted in accordance with the requirements of G 104 and H 7.

(*x*) Where the refrigerating machines or air cooler fans are driven by steam engines particulars and plans are to be submitted in accordance with G 104.

(*y*) Where air cooler or necessary air stirring fans are electrically driven plans of the motors are to be submitted in accordance with M 430.

(*z*) Where it is proposed to apply centralised, bridge or automatic controls, a description of the scheme and particulars of the spares to be carried are to be submitted.

**Refrigeration required in excess of N 306**

**203** Refrigeration required in excess of that specified in N 306, which may be necessary for rapid cooling of chambers, or cooling cargoes loaded at temperatures above the carrying temperature, is to be in accordance with a specification approved by the Owners.

**Rate of Air Circulation**

**204** Where refrigeration is effected by forced air circulation over coolers the proposed fan output in each chamber will be considered in relation to the heat to be removed, the nature of the cargo and the service(s) intended.

Where chambers are intended for the additional duties mentioned in 203 the rate of air circulation is to be in accordance with the Owners' requirements.

**Subsequent Modifications or Additions**

**205** Any subsequent modifications or additions to particulars and/or arrangements shown on the approved plans or in the specifications are also to be submitted for approval.

**Novel Arrangement and Designs**

**206** Where the proposed construction of the refrigerating plant or refrigerated chambers is novel in design or involves the use of unusual material, special tests may be required, and a suitable class notation may be assigned when the Committee consider this necessary.

**Survey Requirements**

**207** From the commencement of the construction and installation of the refrigerating plant and of the insulation and fitting out of the cargo chambers, to the testing of the completed installation, the Surveyors are to examine the materials and workmanship and are to indicate at the earliest opportunity and require the rectification of any items not in accordance with the Rules or the approved specifications and plans, or any material, workmanship or arrangement found to be defective or unsatisfactory.

## Section 3

### REFRIGERATING PLANT

**Definition of a Unit**

**301** A refrigerating unit comprises a prime mover, one or more refrigerating machines (refrigerant gas compressors), one gas condenser—and in the case of a secondary refrigerant, one brine cooler (gas evaporator)—and the fittings necessary to permit independent operation of the unit.

**302** If the prime mover of a refrigerating machine is a steam engine with two or more cylinders and each cylinder drives a corresponding compressor, or there is more than one motor similarly arranged, and if each compressor is connected to its own condenser and brine cooler (where fitted), the arrangement is to be regarded as two or more units as the case may be, provided the units can be used separately or in combination.

NOTE.—Condensers or evaporators of the coil-in-casing type need not necessarily be in separate casings.

**303** Two or more refrigerating machines (or compressors) driven by a single prime mover, or having only one condenser or one brine cooler (where fitted), are to be regarded as one unit.

**304** Where a refrigerating plant is provided for sub-cooling the liquid refrigerant, or cooling the condensers of other refrigerating machines, and is not arranged for cooling the cargo spaces independently, it will not be regarded as a unit.

**305** Where a refrigerating plant is dependent on the main refrigerating units for cooling the condenser or the refrigerant liquid, it will not be regarded as a unit.

**Refrigeration to be Provided**

**306** The refrigeration provided is to be capable of efficiently maintaining the minimum temperature(s) under the conditions applicable to the maximum sea temperature for which approval by the Committee is desired and which is to be specified in the class notation (*see* N 101), when working 24 hours a day with any one of the refrigerating units out of action. It is recommended that a reasonable margin in plant output over maximum load be allowed for possible overall inefficiencies under service conditions.

**307** Where part of the necessary refrigeration is obtained by the sub-cooling of the liquid refrigerant by other refrigerating plant, one plant supplying such sub-cooling may be considered sufficient provided the refrigerating units including the stand-by unit are capable of the full duty specified in 306 in the event of the sub-cooling plant being out of action.

**308** In any case where all the refrigerating units are not connected for use on all the refrigerated cargo chambers the plant serving each chamber is to comply with the requirements of 306.

**309** The foregoing requirements are based on the assumption that installations will have relatively few refrigerating units each arranged to serve all chambers. In the case of installations having a large number of small units arranged to serve individual chambers, or groups of chambers, the question of reserve plant will be the subject of special consideration.

**Number of Refrigerating Units**

**310** Not less than two complete refrigerating units are to be fitted. Where two units only are fitted the working parts are to be interchangeable.

**Stand-by Pumps**

**311** A stand-by gas condenser cooling water pump is to be installed ready for use in addition to the pumps required for the full duty specified in 306. This stand-by pump may be one of the pumps used for other purposes provided it is of adequate capacity and its use on the gas condenser does not interfere with other essential services.

**312** Where brine is used for refrigerating the cargo chambers a stand-by brine circulating pump is to be installed ready for use in addition to the pumps required for the full duty specified in 306.

**Sea Connections**

**313** Condenser cooling water is to be taken from not less than two sea connections, one of which may be that provided for other purposes, such as the water ballast inlet. It is recommended that one of the sea connections be provided on the port and the other on the starboard side.

**Location of Machinery**

**314** Where ammonia refrigerant is used the refrigerating machinery is to be in an efficiently ventilated compartment isolated from the propelling machinery spaces and shaft tunnels, and living quarters.

Machinery using non-toxic and non-inflammable refrigerants will not be subject to restriction on location in general, but proposals to install relatively large plants in propelling machinery spaces will require special consideration.

**Prime Movers**

**315** Where refrigerating plant is electrically driven the motors and their control gear are to comply with the requirements of M 4 and M 7.

**316** Where the refrigerating machinery is steam driven the steam engines are to comply with the requirements of Chapters G and H and the exhaust steam is to be led to the main and auxiliary condensers.

**317** Where the refrigerating machinery is driven by oil engines the requirements of Chapters G and H are to be carried out.

### Motive Power

**318** In the case of 315 the electric power is to be taken from at least two generators (*see also* M 403) and in the case of 316 steam is to be taken from at least two boilers, each capable of the maximum duty without interference with other essential services.

### Plant on Ships not classed with the Society

**319** In the case of refrigerating installations being constructed under the Society's Special Survey on ships not intended to be classed with this Society, the generator engines and electrical equipment, which supply power to the refrigerating installations, should be constructed in accordance with the requirements of the Classification Society concerned, but such plant is to be examined generally and under working conditions.

### Steel Castings

**320** Important steel castings are to comply with the requirements of P 5.

### Steel Forgings

**321** Crank shafts and other important steel forgings are to comply with the requirements of P 6.

### Dimensions of Crank Shafts

**322** Crank shafts of single acting reciprocating refrigerant compressors, of mild steel having a tensile breaking strength of 44-50 kg. per mm.$^2$ are to have dimensions not less than those calculated from the following formulæ.

Where crank shafts are proposed to be made of steel of greater strength or of other material, the particulars including the material specification are to be submitted for special consideration.

**323** The formulæ are applicable to compressors operating on the normal cycle, with crank shafts having one, two, three or four cranks at equal angles and one cylinder acting on each, and with two or more main bearings.

**324** The formulæ are also applicable to compressors, other than $CO_2$ having the crank and cylinder arrangements as shown in the following table, but in these cases the calculated shaft diameter is to be increased by 5%, 18% and 25% when the angle between cylinders is 90°, 60° and 45° respectively.

| Number of crank pins | Number of cylinders per crank | Angle between cylinders |
|---|---|---|
| 1 or 2 | 2 | 45°, 60° or 90° |
| 3 | 2 | 45° or 60° |
| 4 | 2 | 45° or 60° |
| 1 | 3 | 45°, 60° or 90° |
| 2 | 3 | 45° or 60° |
| 3 | 3 | 45° |
| 1 | 4 | 45° or 60° |
| 2 | 4 | 45° |

**325** The formulæ are not applicable to crank shafts having more than one crank on the same top centre, or to compressors where the cylinders are arranged for supercharging by gas of higher pressure at an intermediate stage of the stroke.

### Diameter of Crank Shafts

**326**

| Refrigerant | Diameter of crank shaft (All dimensions in inches or millimetres) |
|---|---|
| Carbon Dioxide ($CO_2$) | $\sqrt[3]{\frac{D^2\left(15\frac{ab}{a+b}+1{,}25S\right)}{12}}$ for gas discharge pressures up to 105 kg. per cm.$^2$ |
| Ammonia ($NH_3$) Monochlorodifluoromethane ($CH\,Cl\,F_2$) | $\sqrt[3]{\frac{D^2\left(2{,}5\frac{ab}{a+b}+0{,}15S\right)}{12}}$ for gas discharge pressures up to 17,5 kg. per cm.$^2$ |
| Dichlorodifluoromethane ($C\,Cl_2\,F_2$) | $\sqrt[3]{\frac{D^2\left(1{,}5\frac{ab}{a+b}+0{,}1S\right)}{12}}$ for gas discharge pressures up to 10,5 kg. per cm.$^2$ |

where D = cylinder diameter,

S = length of stroke,

a = distance from the inner edge of one bearing to the centre line of the crankpin nearest the centre of the span,

b = distance from the centre line of the same crankpin to the inner edge of the other bearing,

a + b = distance (or span) between the inner edges of adjacent main bearings.

**327** Where it is proposed to make solid forged crank shafts of steel having a specified minimum tensile strength greater than 44 kg. per mm.$^2$, but not exceeding 80 kg. per mm.$^2$, the diameter of the crank shaft is not to be less than given by the following formula:—

$$\text{Diameter of crank shaft in millimetres} = d \times \sqrt[3]{\frac{44}{0{,}72T + 12{,}6}}$$

where $d$ = diameter, in millimetres, of crank shaft made of steel having a specified minimum tensile strength of 44 kg. per mm.$^2$ as required by 326,

$T$ = proposed specified minimum tensile strength in kg. per mm.$^2$

**Crank Webs**

**328** Crank webs are to be of the following proportions or of equivalent strength :—

Breadth of web = 1,33 × calculated shaft diameter
Thickness of web adjacent to a bearing = 0,56 × calculated shaft diameter
Thickness of intermediate webs = 0,75 × calculated shaft diameter

## CAST IRON CRANK SHAFTS

**General**

**329** Where it is proposed to make crank shafts of cast iron, the material specification and the dimensions of the shaft are to be submitted for special consideration.

**Material**

**330** The material specification should state the type of cast iron, the heat treatment, and mechanical properties, including the specified minimum tensile strength appropriate to the section of the crank shaft casting.

**331** Any suitable type of high duty cast iron may be used, provided the minimum specified tensile strength is between 32 and 76 kg. per mm.$^2$ Crank shafts are to be cast at a foundry approved for the production of cast iron crank shafts. (*See* P 19).

**Crank Shafts**

**332** The diameter of the crank shaft is not to be less than that given by the following formula:—

$$\text{Diameter of crank shaft in millimetres} = d \times \sqrt[3]{\frac{22}{0{,}3T + 7{,}9 - \frac{d}{48}}}$$

where $d$ = diameter in millimetres required by 326 for a steel crank shaft having a tensile strength of 44 kg. per mm.$^2$

$T$ = specified minimum tensile strength of cast iron in kg. per mm.$^2$ which is not to be less than 32 kg. per mm.$^2$

**333** Special consideration will be given to crank shafts which have been designed and developed for optimum fatigue strength with cranks of the most favourable shape, and some allowance made for the superior strength thereby obtained. Particulars of any relevant tests or experience should be submitted.

**Crank Webs**

**334** The proportions of the crank webs are to be as stated in 328.

**Fillets and Oil Holes**

**335** Fillets at the junctions of crank webs with crank pins or journals are to be machined to a radius of not less than 5 per cent of the diameter of the crank shaft and are to have a smooth finish.

Oil holes at the surfaces of crank pins and journals are to be rounded to an even contour with a smooth finish.

**Crank Shafts for Compressors of Other Designs**

**336** The particulars of crank shafts for double acting or compound compressors, and for other refrigerants or arrangements, are to be submitted for special consideration.

**Maximum Working Pressures**

**337** The components of primary refrigerant pressure systems including piping, stop valves and headers are to be designed for a maximum working pressure of not less than :—

105 kg. per cm.$^2$ for carbon dioxide ($CO_2$)

17,5 kg. per cm.$^2$ for ammonia ($NH_3$) and monochlorodifluoromethane ($CH\,Cl\,F_2$)

10,5 kg. per cm.$^2$ for dichlorodifluoromethane ($C\,Cl_2\,F_2$)

In the case of crankcases which are exposed to the refrigerant pressure the design pressure is to be not less than :—

14 kg. per cm.$^2$ for ammonia and monochlorodifluoromethane

7 kg. per cm.$^2$ for dichlorodifluoromethane

Crankcases designed for a lower pressure are to be provided with a pressure relief valve arranged to lift at the design pressure and the discharge led to a safe place.

If desired a lower design pressure may be considered for other parts of the low pressure side of the system.

The design pressure for other refrigerants which may be proposed will be considered on application, but as a general guide this will be the saturated vapour pressure at 46° C.

### Refrigerant Pressure Vessels

**338** Welded cylindrical pressure vessels which are of steel construction and exposed to the pressure of the refrigerant are to be constructed in accordance with the requirements of J 18 to J 23 so far as applicable, except that the pressure tests are to comply with 346.

**339** Where ammonia is the refrigerant, pressure vessels are to be constructed to not less than Class 2 fusion welded or Class 1 forge welded requirements.

**340** Where pressure vessel shells are made of steel tube the tubes are to comply with the requirements of E 5 so far as applicable, except that the formula for determining the thickness of straight shells may be modified to

$$t = \left(\frac{WP \times D}{2f} + 0{,}75\right) 1{,}15$$

**341** Where ammonia is the refrigerant, pressure vessel shells are not to be manufactured from lap welded pipes.

**342** Where pressure vessels are of seamless construction, they are to comply with the requirements of J 2405 to J 2407, and the pressure tests are to comply with 346.

**343** Where it is proposed to construct pressure vessels of materials other than steel, or not of cylindrical form, full particulars will be required for special consideration.

### Pressure Pipes

**344** Steel piping for primary refrigerants is to comply with the requirements of E 5 except that the figure of 1,25 may be reduced to 0,75 and the pressure tests are to be in accordance with 346.

Butt welding of pipe lengths in lieu of flanged joints is to be carried out as required in E 5 under the supervision and to the satisfaction of the Surveyors.

Where the pipes are galvanized, a short part at the ends about 100 mm. long, is either to be left ungalvanized or the galvanizing is to be removed before welding.

**345** Where it is proposed to use pipes of materials other than steel, full particulars are to be submitted for consideration.

### Pressure Tests

**346** The pressure tests which follow are to be witnessed by the Society's Surveyors at the makers' works. The hydraulic test may be carried out with any suitable liquid. When it is inconvenient to test the large $NH_3$ (ammonia) condensers and evaporators by submersion in water the shells may be charged with air and gas, and tested by some suitable means. In the case of $C\,Cl_2\,F_2$ (dichlorodifluoromethane) and $CH\,Cl\,F_2$ (monochlorodifluoromethane) a suitable gas may be used in lieu of air.

| Refrigerant | Component | Minimum Test Pressure kg./cm.² | |
|---|---|---|---|
| | | Hydraulic | Air* |
| $CO_2$ | Compressor cylinder blocks, stop valves and connections, connecting piping, separators, condenser and evaporator coils and all components subject to gas pressure. | 210 | 105 |
| $NH_3$ and $CH\,Cl\,F_2$ | Compressor cylinders, stop valves, connections and all piping. | 42 | 21 |
| | Compressor crankcases subject to refrigerant pressure. | 21 | 10,5 |
| | Condenser, evaporator and air cooler coils. | 105 | 35 |
| | Condenser and evaporator coils or grids welded to headers; condensers and evaporators of double pipe or "shell and tube" types; pressure vessels, and all other components subject to gas pressure. | 35 | 17,5 |
| $C\,Cl_2\,F_2$ | Crankcases subject to refrigerant pressure. | 14 | 10,5 |
| | Small machines with cylinders up to 11,5 cm. dia. where the cylinders and crankcases are in one casting. | 21 | 14 |
| | All other components in the entire system, including piping. | 24,5 | 14 |
| | Cooling liquid side of refrigerant condensers. | 2WP but not less than 1. | |
| Brine | Air cooler coil assembly. | 7 | |
| | Cast iron casings of refrigerant evaporators. | 2WP but not less than 1. | |
| | Steel casings of refrigerant evaporators on suction side of pump. | 2 × head pressure but not less than 2 | |
| | Steel casings of refrigerant evaporator on discharge side of pump. | 2WP but not less than 3,5 | |
| | Open casings of brine evaporators. | Filled to top | |

*Component submerged in water at 32° C.

### Tests after Erection on Board Ship

**347** Carbon dioxide systems are to be examined for gas leaks when the system is charged. Ammonia and monochlorodifluoromethane systems are to be tested to a gas or air pressure of not less than 14 kg. per cm.²

Dichlorodifluoromethane systems are to be tested by a suitable gas to a pressure of not less than 7 kg. per cm.²

Brine systems are to be tested to a hydraulic pressure of double the working pressure but not less than 3,5 kg. per

cm.$^2$ Where the hydraulic test is not reasonably possible, sections of brine leads (service pipes) which have to be insulated before the circuits are complete may be tested by an air pressure of 6 kg. per cm.$^2$

**Oil Separators**

**348** Suitable oil separators with drains are to be provided to the refrigerant lines. If wire gauze is used in the separator it is to be sufficiently robust and supported to prevent disintegration.

**Filters (strainers)**

**349** Suitable filters are to be provided in the refrigerant gas lines to compressors and in the liquid lines to the regulators. Wire gauze in filters is to be sufficiently robust and supported to prevent disintegration. A filter may be combined with the oil separator required by 348.

**Refrigerant Driers**

**350** Driers are to be fitted in monochlorodifluoromethane and dichlorodifluoromethane refrigerant systems, and the arrangement is to be such that the drier can be by-passed, isolated and opened up without interrupting plant operation.

**Brine Systems**

**351** Where brine is the cooling medium it is recommended that the "closed" system with a brine balance tank be adopted in every case.

**Safety Devices**

**352** A pressure relief valve and/or safety disc is to be fitted between each compressor and its gas delivery stop valve, the discharge being led to the suction side of the compressor.

**353** All pressure vessels of refrigerant systems which could become filled with liquid refrigerant and isolated are to be provided with safety discs and relief valves in series, or other approved arrangements, the discharge being led to a safe place above deck.

**354** Suitable spring-loaded safety valves are to be provided to the cooling liquid side of condensers and the brine side of evaporators where the pressure from any pump connected could cause a pressure in excess of the maximum working pressure.

**Access to Plant**

**355** The arrangements are to be such that all components of the refrigerating machinery can be readily opened up for inspection or overhaul. Space is to be provided for the withdrawal and renewal of the tubes in "shell and tube" type evaporators (brine coolers) and condensers.

**356** Where the coils of "coil-in-casing" type evaporators (brine coolers) and condensers are unwieldy and cannot readily be withdrawn, two suitably arranged inspection holes are to be provided in the top plate, in the sides at about half height and in the sides at the bottom. The holes are to be as large as practicable and not less than 230 mm. $\times$ 150 mm.

**Manual Control**

**357** Where plants are operated by thermostatic refrigerant control, efficient manual controls are also to be provided, and the arrangement is to be such that thermostatic controls can be by-passed and isolated.

**Refrigerating Plant of Other Design**

**358** Particulars of refrigerating plant of designs other than those mentioned in these Rules (e.g. steam jet vacuum refrigeration plants) are to be submitted for special consideration.

**Cooling Appliances in Refrigerated Chambers**

**359** Chambers may be refrigerated by pipe grids on the ceiling and sides or by the circulation of air over coolers.

**360** Refrigeration by pipe grids in the chamber is to be effected by the circulation of brine, except in the case of installations or chambers of very small capacity when the direct expansion of the refrigerant will be considered. The pipe grids in each chamber are to be arranged in not less than two sections. Each section is to be fitted with valves or cocks so that it can be shut off.

**361** Either brine or the direct expansion of the refrigerant may be employed in the coils of air coolers. The coils are to be arranged in not less than two sections each of which is to be capable of being readily isolated when necessary.

**362** The brine or direct expansion leads to, and returns from, the cooling appliances in each chamber are preferably to be in duplicate.

**363** In order to minimise the dehydration of the cargo and the frosting of the cooling elements, it is recommended that the cooling appliances in each chamber should be designed to maintain the required minimum temperature under the maximum difference of not more than 4,5° C. between the cooling medium and the chamber.

**364** Where the joints of brine pipes are made by screwed couplings, the pipes, coupling and back nut threads

are to be a good fit and the thickness of the pipes at the bottom of the screw thread is to be not less than 2,5 mm.

**365** Where the joints of air cooler and grid piping are butt welded they are to comply with 344.

**366** Steel brine and refrigerant piping, grids, joint sleeves and coils within the refrigerated cargo chambers, or where embedded in insulation, or individually insulated are to be galvanized externally. Where such pipes are connected by screwed couplings or by butt welds, the screw threads clear of the couplings or the butt welds and the adjoining ungalvanised portions of the piping, are to be suitably coated and taped after pressure testing to prevent corrosion. The locations of the joints are to be marked on the outside of the insulation.

**367** Brine tanks and piping should not be galvanized on the brine side. In cases where any parts of the brine system are so treated, the brine cooling and return tanks, if closed, are to be provided with a ventilating pipe or pipes led to the atmosphere in a location where no damage will arise from the gas discharged, and the ventilating pipes are to be fitted with wire gauze diaphragms which can readily be removed. Where the brine tanks are not closed, the compartments in which they are situated are to be efficiently ventilated.

**368** Means are to be provided for defrosting air coolers.

**369** Air coolers are to be provided with trays of suitable depth arranged to collect all water condensate. The trays are to be provided with drains at the bottom so that the whole of the condensate can be drained away when the chambers are in service.

**370** Access arrangements to air cooler fans and fan motors are to be such that both fans and motors may be readily removed for repair or renewal when the chambers are loaded with refrigerated cargo. Access for servicing only is required in cases where duplicate fans and motors, each capable of the full duty, are installed ready for use; this also applies to centrifugal type fans but not to their motors.

**371** The air circulation system is to be arranged for positive air delivery to, or suction from, all parts of the chamber, including any space within hatch coamings.

**372** Where it is intended to carry fruit cargoes, which may be adversely affected by low temperatures, into sea areas where the temperature may be below the carrying temperature, facilities for heating the chambers are to be provided.

**Air Refreshing Arrangements**

**373** Where chambers are intended for the carriage of gas-generating cargoes, air refreshing appliances are to be provided.

The position of the air inlets is to be carefully selected to minimize the possibility of vitiated air from any source entering the chambers. Each chamber is to be provided with individual inlets and discharges, having airtight closing appliances.

## Section 4

## CARGO CHAMBERS

**Construction**

**401** Each individual chamber is to be of steel construction throughout and hose-tested for tightness, or tested more thoroughly by gas and air under slight pressure when required by the Owners.

**402** At the request of Owners, special consideration will be given to the construction of divisional bulkheads of materials other than steel, between refrigerated cargo chambers where the chambers concerned are intended for cargoes which will not taint or otherwise adversely affect the cargo in any other chamber.

NOTE.—Gases given off by one description of fruit may adversely affect other descriptions by promoting rapid ripening.

**403** Hatch plugs and their supports, chamber, air cooler and other access doors, tonnage openings, bilge limbers and plugs are to be made as airtight as possible.

**404** Ventilators, ducts or pipes passing through refrigerated chambers to other compartments are to be made airtight and efficiently insulated. Ventilators to refrigerated spaces, if fitted, are to be provided with airtight closing appliances.

**Airtightness of the Bulkheads and Decks**

**405** Where refrigeration pipes pass through bulkheads or decks of refrigerated cargo chambers they are not to be in direct contact with the steelwork, the holes through which they pass are to be true and of suitable finish for effectively sealing by the method intended. It is recommended that holes be trepanned and not burnt out. The airtightness of the bulkheads and decks is to be maintained (*see also* 408 and 413).

**Airtightness of Chambers**

**406** The foregoing paragraphs, 401 to 405, are mainly concerned with infiltration of odours, gases, water vapour and air, which may taint or adversely affect the refrigerated cargo or the insulation, or cause undesirable frosting of cooling equipment. With this object in view it is also

recommended that insulation lining, bilge limbers and plugs, hatch plugs, chamber and access doors be constructed of water vapour-resisting material, or covered with such material, and sealed, where exposed to bilges or external conditions.

**Insulation**

**407** Steelwork is to be thoroughly cleaned and coated in accordance with D 3003 and D 3004 and is to be examined for airtightness of fittings before insulation is applied.

Insulating material approved by the Committee is to be used throughout, and the thickness of insulation over all surfaces and the manner in which it is supported are to be in accordance with the approved specification and plans.

The insulation is to be efficiently packed and, where it is of slab form, the joints are to be butted closely together and staggered, unavoidable crevices being filled with insulating material. Bitumen should not be used for filling crevices.

**408** Pipes carrying the refrigerating medium are not to be in contact with the steel structure and are to be effectively insulated outside the chambers they serve, except within insulated brine cooler and control rooms (*see also* 405 and 413).

**Cross-references**

**409** For insulation of oil storage tank tops and bulkheads, *see* E 345 and E 346.

For pipes in refrigerated spaces, *see* E 416 to E 418.

For drainage of refrigerated spaces and cooler trays, *see* E 211 to E 216.

For use of fork lift trucks in refrigerated spaces, *see* D 1108.

**Protection of Insulation**

**410** The insulation in way of the hatchways and about 0,6 metres beyond on the tank top and the tunnel top is to be protected with hardwood sheathing about 50 mm. thick, or to have similar protection.

**Access Plugs and Panels**

**411** Insulated plugs are to be provided in the insulation where required for easy access to the bilges, bilge suction roses, cooler and space drains and tank manhole doors. Removable panels are to be provided for access to tank air and sounding pipes and drains.

It is recommended that, where no air space is provided below the insulation on the tank tops and the floor covering above the insulation is reinforced asphalt, a number of small insulated inspection plugs be fitted for leakage detection.

Where "loose fill" insulation is fitted and lined with metal it is recommended that airtight inspection plates be provided at the top of vertical surfaces to facilitate inspection and making good any settlement.

**Fire-resisting Insulation**

**412** The insulation in way of coal bunkers and of any surfaces exposed to excessive heat is to be of approved fire-resisting material. Where wood grounds are used for supporting insulation, asbestos strips are to be fitted between the wood grounds and the steelwork to which they are attached.

Where pipes carrying the refrigerating medium pass through bunkers the pipes may be packed with granulated cork but there is to be a thick outer covering of fire-resisting material and the whole is to be protected by steel plates which are to be sealed for airtightness.

**Watertight Bulkhead Fittings**

**413** Where cooling pipes pass through watertight deck plating and bulkheads, the pipes are not to be in contact with the steelwork, and the fittings and packings of the glands are to be both fire-resisting and watertight (*see also* 405 and 408).

**Airtightness of Insulation Lining and Air Ducts**

**414** Air ducts and insulation linings are to be so constructed and fitted that moving air is prevented from entering the insulation. Special care is necessary where cooling pipes, air refreshing ducts, fan supports, etc., protrude through the lining.

**Cargo Battens**

**415** Cargo battens of about 50 mm.×50 mm. and spaced approximately 0,4 metre apart are to be secured to the vertical surfaces of the chambers clear of air ducts, screens and cooler casings, and are to be fitted to suit the air flow. The outer edges of the battens are to be chamfered.

**416** Cargo battens of not less than 75 mm.×75 mm. are to be secured over the tunnel top insulation.

**Stiffening of Insulation Linings and Air Ducts**

**417** Insulation linings and air screens on the sides of chambers are to be suitably stiffened to prevent crushing by cargo, in particular where ship sides are curved inwards and according to the nature of the cargo, whether general or refrigerated, which the owners intend to carry in the chambers. Air duct sides or insulation linings which may have to support heavy loads are to be constructed to Owners' requirements.

**Thermometers**

**418** Thermometers are to be of approved type, number and position in each chamber.

**419** Thermometer tubes with their flanges and covers are to be insulated from the deck plating, and on weather decks they are to be so arranged that water will not run down the tubes when taking the temperatures.

**420** The inside diameter of thermometer tubes is to be not less than 50 mm. and the tubes are not to be in contact with cold decks.

**421** Where thermometer tubes pass through compartments other than that which they serve, they are to be efficiently insulated.

**Galvanizing of Fixtures**

**422** All steel bolts, nuts, hangers, brackets and fixtures which support or secure cooling appliances, insulation, meat rails, etc., are to be galvanized.

## Section 5

### TESTS AFTER COMPLETION

**Thermometers**

**501** All thermometers provided for measuring chamber, air suction and air delivery temperatures are to be checked for accuracy by the contractors and a statement handed to the Surveyors. The Surveyors may use their discretion as to whether check tests are necessary.

**Air Cooler Fan Outputs and Air Circulating Arrangements**

**502** Air cooler fans are to be tested by the contractors after the air circulating system has been completed and a statement of the results for each chamber handed to the Surveyors. The statement is to show the static pressure, the cubic feet of air circulated per minute, the fan speed and the power consumption. The air circulation arrangements in the chambers are to be checked for distribution.

**Refrigeration Test**

**503** All plant is to be tested under working conditions and the capabilities of the installation checked by a heat balance test.

Before the commencement of the test the Surveyors are to satisfy themselves that the electrical instruments, gauges and thermometers are accurate.

The chambers are to be cooled down to the temperatures required in the class notation, but not necessarily at the balance period. Unless the decks are insulated so that the steel is exposed to the ambient temperature (*see* D 3107) the chamber temperatures are not to be reduced by more than 1° C. below the notation temperatures except by special arrangement and with the agreement of the Owners and the Builders.

When the chamber balance test temperatures have been reached they are to be maintained constant for a stabilising period during which heat is removed from the insulation, etc., in the chambers, and thereafter the temperatures maintained constant for a balance period of six hours, or longer if found necessary.

To maintain steady balance temperatures compressor speed or power input to the fan motors may be varied, or if necessary compressors may be run on stop-start cycles. Cylinder unloading should be avoided where possible and devices for varying cylinder duty should not be used. All such adjustments and stop-start cycles are to be carefully logged.

**504** Observations are to be recorded from the beginning of cooling down to the end of the test. In the early stages logging may be at intervals of about four hours, but external temperatures should be logged hourly for the final eighteen hours of the test, and all other relevant temperatures and pressures, speed and power consumption of compressor and fan motors, power consumption of brine and cooling water pumps logged hourly for the final twelve hours of the test.

**505** Where an installation is to be completed and tested during a period when extremely low external temperatures are probable and a reasonable difference between the external and internal temperatures will not be possible without reducing the chamber temperatures below the level referred to in 503, the case is to be submitted for special consideration.

**506** In cases where it is reasonable to believe that the refrigerating plant is inefficient an output test on the plant may also be required.

**Air Cooler Defrosting Arrangements**

**507** The air cooler defrosting arrangements are to be tested.

## Section 6

### SPARE GEAR

**601** The following spare gear will be required in all cases :—

1 fan impeller of the propeller type of each size used.

1 set of the wearing parts of the crank shaft seals for each compressor where the crank case is subject to the refrigerant pressure.

1 set of crank shaft coupling bolts of each size used.

1 set of motor coupling bolts and washers, of each size used.

1 compressor piston with piston or connecting rod complete, of each size used.

1 complete assembly of each size of compressor suction and delivery valve.

1 complete set of packing for $CO_2$ compressor piston rod glands of each size used.

1 set of the working parts, together with packing and piston leathers, for the lubricating oil pump for $CO_2$ compressor rod glands.

1 gas regulator valve of each size used.

1 float regulator assembly of each size used.

1 set of suction and delivery valves for cooling water, air and brine pumps, of each size used.

1 set of driving belts of each size used.

Sundry lengths and bends of piping together with flanges, couplings and screwing appliances.

Sundry cocks, valves, flanges and fittings.

Assorted bolts, nuts, studs, packing and joint rings.

5 per cent of the total number of electrical or tube thermometers, but not less than two of each.

Not less than two standard thermometers of the necessary temperature range.

1 spare battery for each electric thermometer indicator fitted.

1 hydrometer, where brine is the cooling medium.

1 halide lamp leak detector, where dichlorodifluoromethane or monochlorodifluoromethane is the refrigerant.

2 safety valve springs of each size used.

6 safety discs of each size used.

In cases where approval is given to alternative arrangements under N 104, additional spare gear may be required according to the circumstances of the case.

**602** Where steam driven air circulating fans are fitted, the following spare gear will be required :—

For each size used :—

1 crank shaft.

1 steam piston and rod complete.

1 steam cylinder cover.

1 set of connecting rod top and bottom end bearing bushes, and bolts complete.

**603** Where the refrigerating machines are direct driven by steam engines or by oil engines, the spare gear is to be in accordance with Chapter K.

**604** Where any component of the refrigerating plant is electrically driven the spare gear is to be in accordance with M 2002, and in the case of fan motors, M 2004, except where a duplicate fan motor (*see* N 370) is installed ready for use.

**605** It is assumed that the Owners will arrange for the necessary reserve supply of the refrigerant, calcium chloride and oils for the voyage intended.

## Section 7

### INSTALLATIONS NOT CONSTRUCTED UNDER SURVEY

**701** When classification is desired for an installation not constructed under the supervision of the Society's Surveyors, application is to be made to the Committee in writing.

**702** Full particulars and plans are to be forwarded for consideration, together with the particulars of the materials of the crankshafts, pressure vessels and pressure piping. The requirements of N 202 are to be used for guidance in regard to the information required.

**703** A special examination is to be made at least to the extent required for Subsequent Special Surveys. (*See* N 863 to N 868.)

**704** The thickness and material of the insulation, the particulars of the frames, beams, stiffeners and other steel work within the insulation, the air coolers and/or chamber grid piping, the compressors, evaporators and condensers are to be verified, and the particulars of the other components of the refrigerating plant are to be verified so far as practicable.

**705** The installation is to conform with the requirements of N2, N 3, N 4 and N 6, so far as applicable.

**706** A test is to be carried out in accordance with N 503 to N 505, and air circulation arrangements in the chambers are to be checked for air distribution.

## Section 8

### PERIODICAL AND OTHER SURVEYS

#### Incidence of Surveys

**801** For the retention of the class assigned, installations are to be subjected to the periodical surveys specified in the following paragraphs.

**802** Where desired by the Owners, the Intermediate and Running Surveys may be held at shorter intervals than those specified in 805 and 806, for a fresh record of Survey and the issue of a new Certificate.

**803 A Loading Port Survey,** as detailed in 817 to 821, is to be held at the loading port every voyage in the case of ships engaged on voyages of more than two months' duration, but where the voyages are of shorter duration, this survey need only be held at intervals of two months, provided the cargoes carried are of such a nature as not to damage the insulation or appliances in the insulated chambers nor to affect by taint or mould the refrigerated cargoes subsequently loaded.

**804 A Biennial Survey,** as detailed in 822 to 846, is to be held, the first 2 years after the date of the survey for Classification, and thereafter two years from the date of the previous Biennial Survey.

**805 An Intermediate Survey,** as detailed in 847 to 849, is to be held about twelve months after the date of the survey for Classification and about twelve months after each Biennial Survey.

**806 Running Surveys** as detailed in 850 to 854 may be held, if desired by the Owners, at intervals of twelve months in lieu of the Intermediate and Biennial Surveys.

**807** In special circumstances the Committee will be prepared to consider postponement of a Biennial or Running Survey for a period not exceeding two months, provided application is made by the Owners prior to the due date of the Biennial or Running Survey and a Loading Port Survey is carried out as near to this date as practicable.

**808 A Special Survey,** as detailed in 855 to 868, is to be held at 4-yearly intervals, the first 4 years after the date of the survey for Classification, and thereafter four years from the date of the previous Special Survey. The requirements of 859 to 862 of this survey should be carried out whenever possible at the time of the Special Surveys prescribed in B 8, except in the case of small installations where major parts of the ship's structure are not involved.

A Special Survey will normally become due at the same time as a Biennial or a Running Survey, but when they do not coincide and the other Periodical Surveys are held within the specified intervals, the requirements of 856 to 862 and 864 to 868 only of the Special Survey will be necessary, but the date assigned to the Special Survey will be that of the Biennial or the Running Survey.

When it is inconvenient for Owners to fulfil the Special Survey requirements at the due date, the Committee will be prepared to consider its postponement, either wholly or in part, for a period not exceeding twelve months from the due date, provided the other Periodical Surveys continue to be held at the specified intervals.

#### Continuous Special Survey

**809** When at the request of Owners it has been agreed by the Committee that the Special Survey requirements of 859 to 861 may be carried out on the Continuous Survey basis on ships in which the Continuous Hull Special Survey system has been accepted, the insulation in the compartments concerned and the insulation of the refrigerant piping should be exposed or removed as required by the Surveyors, in rotation, so as to ensure that the interval between consecutive examinations will not exceed the period normally allowed by the Regulations between Special Surveys.

If the examination during Continuous Survey reveals any defects, further parts are to be opened up and examined as considered necessary by the Surveyor.

#### Survey of Repairs

**810** Where any essential repairs and/or renewals are effected to an installation, these are to be carried out under the supervision, and to the satisfaction, of the Society's Surveyors. Repairs and renewals effected at ports where there is no Surveyor to this Society are to be surveyed by one of the Society's Surveyors at the earliest opportunity.

#### Alterations and Additions

**811** Plans and particulars of any proposed alterations or additions to the refrigerated cargo chambers or refrigerating plant are to be submitted for approval, and the work is to be carried out under the supervision, and to the satisfaction, of the Society's Surveyors.

#### Record of Surveys

**812** The date following the class notation Lloyd's RMC on the certificate indicates the date of the last Biennial Survey thus:—Lloyd's RMC 2,54, and the date

under this notation indicates the date of the last Intermediate Survey thus:—Lloyd's RMC 2,54. These dates
12,54
will be recorded in the appropriate columns of the Supplement to the Register Book.

**813** When Running Surveys are held in lieu of Biennial and Intermediate Surveys this will be indicated by the class notation Lloyd's RMC (RS) (with date). This date will be recorded in the appropriate column of the Supplement to the Register Book.

**814** The date of the last Special Survey will be indicated by the notation SRMC (with date). This date will be recorded in the appropriate column in the Appendix to the Register Book and the Supplement.

**815** When the requirements of the Continuous Special Survey and all other requirements of Special Survey have been completed a record of SRMC (CSI) with date, will be entered in the Supplement to the Register Book.

### Notice of Surveys

**816** It is the responsibility of Owners to ensure that all surveys necessary for the maintenance of class are carried out at the proper time under the supervision of the Society's Surveyors.

It is, however, the normal practice of the Society to give timely notice to Owners when Periodical Surveys of Refrigerated Cargo Installations become due, but the non-receipt of such notice does not absolve Owners from this responsibility.

### Loading Port Surveys

**817** The chambers are to be examined in an empty state to ascertain that they are clean and free from odour which may adversely affect the cargo to be loaded, that the brine or other refrigerant pipe grids, cooler coils and connections are free from leakage, that the fixed cargo battens on the vertical surfaces are in good order, that cargo gratings or dunnage battens are provided for the floors or decks as required to suit the class of cargo, and that no damage has been sustained to the insulation or its lining prior to the loading of the refrigerated cargo. Any indications of defective insulation not considered to warrant immediate attention should be noted and specially reported.

**818** The Surveyor is to satisfy himself that all scuppers and bilge suctions draining insulated spaces are in good working order, and that the liquid seals are primed.

**819** The refrigerating installation is to be examined under working conditions, and the temperatures in the cargo chambers are to be noted.

**820** If the ship loads at more than one port, one survey only at the first loading port will be required, provided it includes the examination of all the chambers which are to be used for refrigerated cargo during the voyage and general cargo is not subsequently carried in any of the chambers prior to loading the refrigerated cargo.

**821** If there is no Surveyor to the Society available at the loading port(s), or if there is none obtainable from a port within a reasonable distance, the Committee will accept the report of a survey held at the loading port by a surveyor appointed by Lloyd's Agent; or in any case where there is no Lloyd's Agent, the report of a survey held by a reliable surveyor, if available; if no such surveyor is available, a report signed by two competent engineers of the ship will be accepted.

### Biennial Surveys

**822** Whenever possible the machinery in use is to be examined under working conditions on the ship's arrival at the port of discharge before the refrigerated cargo is unloaded, irrespective of whether any further part of the survey is to be held at the port.

**823** The entries in the ship's refrigeration logbook are to be examined in order to ascertain whether the performance of the installation has been satisfactory during the voyage. Breakdowns, irregularities in the working of the plant, or the too frequent or lengthy defrosting of air coolers, are to be noted and reported. This requirement may be carried out after the completion of the discharge before the examination of the cargo chambers.

When refrigerated cargo has not been carried during the voyage immediately prior to the survey the last records are to be examined.

**824** Should the entries in the logbook show that the load on the plant is generally above the normal for the duty involved during the voyage, steps are to be taken to determine the cause and have it dealt with as found necessary.

**825** The cargo chambers are to be examined for condition throughout, with the bilge and manhole plugs removed in the lower holds. Any indication of dampness or leakage into the insulation from tanks, piping within the insulation, scuppers, decks, hatchways or other sources, or of deterioration of attachments and supports of insulation and linings, air ducts, grids or meat rails, is to be investigated and any such defects rectified.

**826** Where no air space is provided below the insulation on tank tops and there is no effective means of detecting leakages into the insulation, the floor covering is to be

drilled and the insulation tested. Tank and tunnel top insulation in way of hatchways is to be similarly tested where dampness is evident.

**827** Where chambers are cooled by forced air circulation and parts of insulation linings or air ducts are removed or repaired, care is to be taken that all joints are sealed to prevent air blowing into the insulation.

**828** Air ducts, air cooler casings, insulation linings and protrusions through the linings are to be examined as far as practicable for condition, and special attention is to be given to the prevention of air blowing into the insulation. Where asphalt or similar material is used for floor covering, the junction with the insulation lining is to be examined for shrinkage which may cause air leakage into the insulation.

**829** Where there is no evidence in the logbook of an abnormal load on the plant or on individual coolers or chamber grids, and there is no visible indication of insulation defects, the removal of parts of air ducts and insulation linings, and the drilling of linings is not required on vertical and overhead surfaces of chambers cooled by forced air circulation. The Surveyor should use his discretion as to whether the linings on these surfaces should be drilled in grid-cooled chambers having regard to the nature of the insulation and the material with which it is lined.

**830** All test holes are to be effectively closed.

**831** Hatch plugs and supports, chamber and access doors and their frames, air refreshing pipe and ventilator closing appliances, bilge and manhole plugs are to be examined for condition and airtightness. Thermometer tubes, their connections and fastenings are to be examined.

**832** The bilges are to be cleaned; suction pipes, suction roses, sounding pipes and scupper non-return valves are to be examined. The Surveyor is to satisfy himself that all scuppers draining the chambers and air cooler trays are in good working order.

**833** Cooling grids, air cooler coils, cooler trays and fans are to be examined. The Surveyor is to satisfy himself that sections of cooler coils or grids are not choked or partially choked.

**834** Brine or water refrigerant pipe grids and cooler coils are to be tested to $1\frac{1}{2}$ times the working pressure or 3 kg. per cm.$^2$ whichever is the greater.

**835** Primary refrigerant pipe grids and cooler coils with their valves and connections are to be examined whilst under the refrigerant pressure prevailing in the system at the time of the survey, with the plant at rest and the regulating valves opened sufficiently to obtain an approximate balance of pressure throughout the system.

**836** The insulation of pipes carrying the refrigerating medium (service pipes, mains, leads and returns) between the chambers and the plant and/or control rooms is to be examined.

**837** Where the refrigerating machinery or its auxiliaries are electrically driven a general examination of all the motors and their control gear and cables is to be made and the insulation resistance measured. The insulation resistance is to be not less than 100,000 ohms, and for the purpose of this test, each item may be taken separately. Where the Owners employ competent and reliable staff or an electrical contractor, the Surveyor may consult their records and, at his discretion, accept megger tests carried out by them.

Generating plant supplying electric power to the refrigerating machinery is to be examined generally, including the plant in operation. The ship's records of examination, overhaul and repair are to be sighted; if no records are available, the ship's personnel are to be consulted in regard thereto. Any part of the plant is to be opened up for examination which the Surveyor may consider necessary. In the case of ships which are not classed with the Society, the Surveyor is also to ascertain that periodical examinations of the working parts continue to be held by the Classification Society concerned.

**838** The primary refrigerant gas and liquid pipes, separators, receivers, driers, filters, condensers and evaporator coil terminals of the "coil-in-casing" type, and the shells of the "shell and tube" type, heat exchangers and all other pressure parts of the system are to be examined externally so far as practicable.

**839** The refrigerating plant spare gear is to be examined.

**840** The thermometers required by N 418 for measuring the chamber, air suction, and air delivery temperatures, are to be examined, and where repairs or renewals are found necessary, the thermometers concerned are afterwards to be tested for accuracy. Each thermometer is to be tested for accuracy at intervals not exceeding the period between Special Surveys; it is not necessary that all are tested at one time. The Surveyor may, at his discretion, accept the results of thermometer tests carried out by competent staff or by a contractor employed by the Owners. Records of tests for accuracy are to be available on board the ship.

NOTE.—In a number of ships, thermometers of a type not approved by the Society have been fitted in addition to those required by N 418; the former need not be examined or tested.

**841** The water end covers of "shell and tube" type gas condensers are to be removed and the tubes and tube plates are to be examined.

**842** All reciprocating refrigerating machines including those provided for primary refrigerant liquid cooling are to be opened up; the cylinders, valves and seats, crankshafts, connecting rods, pistons and piston rods, and all bearings are to be examined. The lower halves of main bearings need not necessarily be exposed if the Surveyor is satisfied with the alignment and wear. The lubricating arrangements are also to be examined.

**843** Where the refrigerating machinery is driven by steam or internal combustion engines, all the working parts of the engines are to be opened up and examined, including all pumps directly driven by the driving engines, in a similar manner to that specified for the refrigerating machines (*see* 842).

Steam condensers exclusive to the refrigerating plant driving engines are also to be examined and, if considered necessary, they are to be tested.

**844** The working parts of all independent gas condenser cooling and brine circulating pumps are to be examined. Where the standby condenser cooling pump is one of the pumps used for other purposes, this pump is also to be examined.

**845** In the case of steam jet vacuum refrigerating plants, which provide the cooling medium circulated through the chamber cooling appliances, the flash chambers and water spray arrangements, the thermo-compressor steam chambers and nozzles, the condensers, the cooled water circulating, the condenser cooling, and the condensate extraction pumps, and the air pumps or ejectors are to be examined and, if considered necessary, the condensers are to be tested.

**846** At intervals of 6 years from the date of construction, the steam pipes to steam engines driving refrigerating machinery and to steam jet vacuum refrigerating plants are to be examined and those pipes over 76 mm. internal diameter are to be included in the survey required by C 10.

In the case of installations on unclassed ships, the Surveyors are to ascertain whether the steam pipes have been similarly dealt with by the Classification Society concerned, and if not, arrangements are to be made for the examination and tests in accordance with C 10.

**Intermediate Surveys**

**847** All the requirements of 822 to 840 (Biennial Survey) are to be complied with.

**848** The water end covers of one of the "shell and tube" type gas condensers are to be removed and the tubes and tube plates are to be examined; if the Surveyor considers it necessary the other condensers of the same type are to be similarly treated.

**849** The whole of the plant referred to in 842 to 845 is to be generally examined and any part is to be opened up for examination which the Surveyor may consider necessary. Any component opened up for overhaul at the time of the survey is also to be examined.

**Running Surveys**

**850** All the requirements of 822 to 840 (Biennial Survey) and 848 to 849 (Intermediate Survey) are to be complied with.

**851** The tubes and tube plates of each "shell and tube" type gas condenser are to be examined at intervals not exceeding two years.

**852** The plant referred to in 842 to 845 (Biennial Survey) is to be opened up and examined in rotation so that the whole of the plant is examined within each period of two years, but one of the main refrigerating machines and, where applicable, its steam or internal combustion driving engine, one of the condenser cooling pumps and, where applicable, one of the brine circulating pumps, are to be examined either at each survey or within the previous six months.

In the case of steam jet vacuum refrigerating plants which provide the cooling medium circulated through the chamber cooling appliances, one of the flash chambers with its water spray arrangements, one of the thermo-compressor steam chambers and nozzles, one of the condenser cooling water pumps and one of the cooled water circulating pumps are to be examined either at each survey or within the previous six months.

**853** *A survey book is to be kept on board the ship to show the date of examination of the various parts, and is to be signed by the Surveyor on the occasion of each survey.*

**854** At intervals of 6 years from the date of construction the steam pipes to steam engines driving refrigerating machinery and to steam jet vacuum refrigerating plants are to be examined, and those pipes over 76 mm. internal diameter are to be included in the survey required by C 10.

In the case of installations on unclassed ships, the Surveyors are to ascertain whether the steam pipes have been similarly dealt with by the Classification Society concerned, and if not, arrangements are to be made for the examination and tests in accordance with C 10.

**First Special Survey**

**855** All the requirements of 822 to 846 (Biennial Survey) are to be complied with except where the surveys are being held in accordance with 806, when the requirements of 850 to 854 (Running Survey) are to be complied with.

**856** Where the refrigerating machinery is driven by internal combustion engines and independent air compressors and air receivers exclusive to the refrigerating plant are installed, the working parts of the compressors and their intercoolers and safety devices are to be examined. The air receivers with their mountings, valves and safety devices are to be cleaned internally and examined internally and externally. If internal examination of the air receivers is not practicable, they are to be tested hydraulically to twice the working pressure.

**857** The Surveyor is to satisfy himself that all pressure relief valves and/or safety discs throughout the refrigerating plant are in good order. No attempt, however, should be made to test primary refrigerant pressure relief valves on board ship.

**858** In the case of steam jet vacuum refrigerating plants installed for sub-cooling the primary refrigerant liquid, the flash chambers and water spray arrangements, the thermo-compressor steam chambers and nozzles, the condensers, the cooled water circulating, condenser cooling and condensate extraction pumps, and the air pumps or ejectors are to be examined and, if considered necessary, the condensers are to be tested.

**859** Sufficient insulation is to be stripped from pipes carrying the refrigerating medium at various points of the system particularly in bunkers or near boilers, on decks or where buried in hold insulation, to permit of the condition of the pipes being ascertained. Care is to be taken that on replacement the seal of the outer covering over the insulation is made good where the pipes are exposed to atmospheric conditions, particularly in bunkers, in accordance with N 412.

**860** Sufficient air trunking and insulation lining is to be stripped from the chamber overhead and vertical surfaces to permit of the condition of the insulation, insulation linings, grounds, supports, hangers and fixtures which support the insulation, grids, meat rails, etc., being ascertained. Care is to be taken that on replacement the ducts and linings are sealed against air blowing into the insulation.

**861** Sufficient tank top insulation is to be stripped to permit of the condition of the grounds and inner insulation lining being ascertained.

**862** Sea connections to condenser cooling water pumps are to be opened up and examined.

**Subsequent Special Surveys**

**863** All the requirements of 855 to 862 (First Special Survey) are to be complied with.

**864** The coils of gas condensers and evaporators (brine coolers) of the "coil-in-casing" type are to be drawn for examination where this is reasonably practicable. In the case of condensers and evaporators which are unwieldy or where there is insufficient head room, an examination of the coils is to be made in place, through the openings in the casings.

The coils of the condensers are to be tested to a pressure of 17,5 kg. per cm.$^2$ for dichlorodifluoromethane systems, 70 kg. per cm.$^2$ for ammonia and monochlorodifluoromethane systems and 140 kg. per cm$^2$. for carbon dioxide systems.

The coils of the evaporators are to be tested to a pressure of 14 kg. per cm.$^2$ for dichlorodifluoromethane systems, 35 kg. per cm.$^2$ for ammonia and monochlorodifluoromethane systems and 105 kg. per cm.$^2$ for carbon dioxide systems.

**865** Gas condensers of the "shell and tube" type are to have the water or brine end covers removed and are to be tested to a pressure of 17,5 kg. per cm.$^2$ for dichlorodifluoromethane systems, and 28 kg. per cm.$^2$ for ammonia and monochlorodifluoromethane systems.

Gas evaporators (brine coolers) of the "shell and tube" type are to have the brine end covers removed and are to be tested to a pressure of 14 kg. per cm.$^2$ for dichlorodifluoromethane systems and 21 kg. per cm.$^2$ for ammonia and monochlorodifluoromethane systems.

**866** Primary refrigerant liquid sub-cooling coils in flash chambers of steam jet vacuum refrigerating plants are to be examined and tested to the same pressure as that required for condensers in 864.

**867** Where brine or water is used for sub-cooling the primary refrigerant liquid in heat exchangers of the "shell and tube" type, the heat exchangers are to be examined and tested in the same manner as that required for condensers in 865.

"Double pipe" type heat exchangers are to be examined so far as practicable with the gas piping under the same pressures as that required for condensers in 865 and the water or brine from the outlets is to be tested for gas leakage.

Other types of heat exchangers using brine or water are to be examined and tested at the discretion of the Surveyor according to the design of such equipment.

**868** Primary refrigerant chamber grids or air cooled coils are to be tested in place to a pressure of 7 kg. per cm.$^2$ for dichlorodifluoromethane, 10,5 kg. per cm.$^2$ for ammonia or monochlorodifluoromethane systems, and 70 kg. per cm.$^2$ for carbon dioxide systems.

## Section 9

## PORTABLE REFRIGERATED CARGO CONTAINERS

### General

**901** Portable refrigerated cargo containers intended to be carried on the owners' ships, which comply with N 1 to N 8 in so far as they are applicable, except as provided in the following paragraphs, will be included in the installations covered by B 901 and B 902.

**902** The shipowners' name and an identification number are to be clearly marked on each container.

**903** Where a container has not been constructed and tested as in the following paragraph 904, it is to be indicated on the container that it is not to be lifted in a loaded condition.

**904** Where a container has been constructed for lifting in a loaded condition a deflection test of the structure is to be carried out on the container, or on a prototype, in a loaded condition under the supervision of the Surveyors.

At this test the container is to be lifted with the cargo space loaded with a uniformly distributed load in three successive stages up to 1,25 times the specified maximum cargo load, and the ratio of the deflection to the length of the container is not to be greater than 1 to 1200.

The empty weight of the container and the maximum cargo load are to be clearly indicated on the container.

**905** A log book showing the particulars of the refrigeration of the container during each voyage is to be maintained, and this is to be made available to the Surveyor at each of the surveys required by 923.

Where the plant is operated by thermostatic control the intervals during which the machinery is working and at rest should be recorded occasionally, particularly during the period of maximum external temperature conditions of each voyage.

### Class Notation

**906** The class notation will be in accordance with N 1 except that where the refrigerant condenser is air cooled the class notation shown in N 101 will give the maximum ambient temperature instead of the maximum sea temperature, e.g., "to maintain temp. 10° F. with ambient temp. 104° F. maximum".

Where the refrigerating machinery is electrically driven and dependent on the ship's generators for power, the class assigned will be subject to suitable electric power being available at all times when the container is loaded with refrigerated cargo.

### Special Survey during Construction

**907** The requirements of N 2 are to be complied with in so far as they are applicable.

### Refrigerating Plant

**908** The requirements of N 3 are to be complied with in so far as they are applicable, except as modified by the following paragraphs.

**909** Where two or more refrigerating units supply refrigeration to a container, or to several containers as a group, the plant is to be capable of efficiently maintaining the minimum internal temperature(s) under the maximum external conditions, to be specified in the class notation, when working 24 hours per day with any one of the refrigerating units out of action.

**910** Where one refrigerating unit supplies refrigeration to a container, or to several containers as a group, the unit is to be capable of efficiently maintaining the minimum internal temperature(s) under the maximum external conditions, to be specifed in the class notation, when working not more than 12 hours per day if the specified conditions are tropical, or not more than 15 hours per day if the conditions are temperate.

**911** Where the refrigerant condenser is air cooled and the maximum gas discharge pressure is above the maxima specified in N 326 and N 337, the design pressure is to be correspondingly increased.

**912** Where the design pressure is increased in accordance with 911, the test pressures specified in N 346 are to be increased proportionately.

**913** Where "shell and tube" type evaporators (brine coolers) and condensers can be readily removed, the space for the withdrawal and renewal of tubes in accordance with N 355 will not be required.

### Cargo Space

**914** The external structure, including the door, is to be of robust design and constructed of, or covered with, water vapour-resisting materials, and the joints are to be effectively sealed. The structure is to be carefully examined for tightness before the insulation is applied. The access door is to be airtight when closed.

**915** The containers are to comply with the requirements of N 404 and N 405, N 407 and N 408, N 414 and N 415, N 417 and N 422 in so far as they are applicable.

**916** Drains of not less than 45 mm. bore are to be provided from the cargo space and air cooler trays, and the drains are to be fitted with means of closure operable from outside the cargo space.

**917** Thermometers are to be of approved type and position in the cargo space. Where thermometer tubes are provided the method of attachment is also to be approved.

**Tests after Completion**

**918** The requirements of N 5 are to be complied with in so far as they are applicable.

**Spare gear**

**919** Where two or more refrigerating units supply refrigeration to a container, or to several containers as a group, as in 909, the spare gear to be carried on the ship with the container(s) is to be in accordance with N 6 in so far as that Section is applicable.

**920** Where a single refrigerating unit supplies refrigeration to a container, or to several containers as a group, as in 910, a complete spare compressor ready for fitting in place is to be carried on board the ship with the container(s), together with the spare gear required by 919, except those items which are included in the spare compressor.

This will apply up to a total of four containers each with a single identical refrigerating unit on one ship. Where the number exceeds four the additional spare gear required will be specially considered.

**921** If at any time a group of containers is divided between two or more ships, spare gear as required by the foregoing paragraphs is to be carried on each ship.

**Containers not Constructed under Survey**

**922** The requirements of N 7 are to be complied with in so far as they are applicable, except as amended by this Section.

**Periodical and other Surveys**

**923** For the retention of the class assigned, periodical and other surveys are to be carried out in accordance with N 8 except as modified in the following paragraphs.

**Loading Port Surveys**

**924** The requirements of N 817 and N 819 are to be complied with and, in addition, the Surveyor is to satisfy himself that the container is placed on board in such a position as to provide free access to the container by the ship's personnel for servicing the refrigerating plant and noting the temperatures; and, where the refrigerant condenser is air cooled, to allow free flow of fresh air to, and heated air from, the condenser.

**925** Generating plant supplying power and the cables and connections to the refrigerating machinery are to be examined generally.

**926** The Surveyor is also to satisfy himself that the drains from the cargo space and air cooler trays are clear and the closing devices are in order.

**927** Where an owner desires a Loading Port Survey of a container which is to be loaded with refrigerated cargo ashore instead of on board the ship, the particular circumstances will require to be specially considered.

**Biennial Surveys**

**928** All the requirements of N 822 to N 831, and N 833 to N 844, except the second paragraph of N 837, are to be complied with in so far as they are applicable.

**929** The cargo space and air cooler tray drains and their closing devices are to be examined.

**Intermediate Surveys**

**930** All the requirements of N 822 to N 831 and N 833 to N 840, except the second paragraph of N 837, and those of N 848 and N 849, and 929 are to be complied with in so far as they are applicable.

**Running Surveys**

**931** All the requirements of N 822 to N 831 and N 833 to N 840, except the second paragraph of N 837, and those of N 848 and N 849, N 851 to N 853, and 929 are to be complied with in so far as they are applicable.

**932** Where one refrigerating unit only is installed the Running Survey system cannot be adopted.

**First Special Survey**

**933** All the requirements of N 856 to N 860 in so far as they are applicable and, in addition, those of 928 and 929 (Biennial Surveys) or, where the surveys are being held in accordance with N 806, those of 931 (Running Surveys), are to be complied with.

**934** Sufficient covering and insulation is to be stripped from the floor of the container to permit of the condition of the insulation, grounds and structure being ascertained.

**Subsequent Special Surveys**

**935** All the requirements of N 864 to N 868, in so far as they are applicable, and, in addition, those of 933 and 934 are to be complied with.

*21st May, 1964*

# Chapter P

# QUALITY AND TESTING OF MATERIALS

*Note:—For list of steel manufacturers see Appendix to this Chapter*

## Section 1

### SHIP, BOILER AND MACHINERY STEEL GENERAL REQUIREMENTS

**Approval of Works and Method of Manufacture**

**101** The steel shall be manufactured at works approved by the Committee, by the open hearth or electric furnace process, or by other process specially approved by the Committee.

**Testing and Inspection**

**102** The prescribed tests and inspection shall be carried out at the place of manufacture before despatch, but in the event of any material proving unsatisfactory during working or fabrication, such material shall be rejected notwithstanding any previous certificates, and the Surveyor may require further tests from other materials from the same batch.

All the test pieces are to be selected and stamped by the Surveyor or an authorised deputy and tested in his presence.

**Surface Inspection and Dimensions**

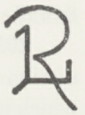
**103** Surface inspection and verification of dimensions are the responsibility of the steelmaker, and acceptance by the Surveyors of material later found to be defective shall not absolve the steelmaker from this responsibility.

**Identification of Materials**

**104** The steelmaker shall adopt a system for the identification of ingots, slabs and finished pieces which will enable the material to be traced to its original heat, and the Surveyors shall be given full facilities for so tracing the material when required.

**Branding**

**105** Every finished item is to be clearly marked by the makers in at least one place with the Society's brand and the following particulars:—



(i) Agreed identification mark for the grade of steel.
(ii) Name or initials to identify the steelworks.
(iii) Number and/or initials to identify the heat.
(iv) Purchaser's identification mark if required by the purchaser.

Where a number of light materials are securely fastened together in bundles, the manufacturer may, subject to the agreement of the Surveyors, brand only the top piece of each bundle, or alternatively, a firmly fastened durable label containing the brand may be attached to each bundle.

**Defacing of Rejected Material**

**106** In the event of any material, bearing the Society's brand, failing to comply with the test requirements, the brand is to be unmistakably defaced.

**Mill Sheets**

**107** The Surveyor shall be supplied with at least two copies of the mill sheets or shipping statements of all accepted material which documents should be separate for each grade of steel. The documents shall contain, in addition to the description, dimensions, etc., of the material, the following particulars:—

(i) Purchaser's identification marks.
(ii) Identification of the heat.
(iii) Identification of the steelworks.
(iv) Identification of the grade of steel.
(v) Ladle analysis (elements controlled by the specification only).
(vi) Order or ship number for which intended.
(vii) If the ship steel is of rimming quality, this should be stated.

**Maker's Certificate**

**108** Before the mill sheets or shipping statements are signed by the Surveyor, the manufacturer is required to furnish him with a certificate stating the material has been made by an approved process and that it has been subjected to and has withstood satisfactorily the required tests in the presence of the Surveyor or his authorised deputy. The following form of certificate will be accepted if stamped or printed on each mill sheet with the name of the steelworks and initialled for the makers by an authorised official:—

"We hereby certify that the material herein described has been made by the.....process (process to be stated) approved by and in accordance with the Rules of Lloyd's Register of Shipping for Grade.....steel, and is that which has been tested in the presence of the Society's representative with satisfactory results".

### Facilities for Inspection

**109** The manufacturers shall afford the Surveyors all necessary facilities and access to all relevant parts of the works to enable them to verify that the approved process is adhered to, and for witnessing the selection and testing as required by the Rules, and for verifying the accuracy of the testing equipment.

### Steel not Produced where Rolled

**110** When steel is not produced at the Works at which it is rolled, a certificate shall be supplied to the Surveyor at the rolling mill stating the process by which it was manufactured, the name of the manufacturer who supplied it, the number of the heat from which it was made and the ladle analysis. The works at which the steel was produced must be approved by the Committee.

### Tensile Test

**111** The tensile tests shall be carried out by competent personnel in an approved machine of adequate capacity. The machine shall be maintained in a satisfactory and accurate condition and shall be re-calibrated at approximately annual intervals. This calibration is to be carried out by a nationally recognised authority or other organisation of standing and is to be to the satisfaction of the Surveyor. A record of all calibrations shall be kept available in the test house.

The tensile strength is defined as the maximum load divided by the original cross-sectional area of the tensile test piece.

## Section 2

## STEEL FOR HULL STRUCTURES

NOTE.—*These requirements are primarily intended to apply to steel not exceeding 50 mm. in thickness. For greater thicknesses, certain variations in the requirements may be allowed or required in particular cases after consideration of the technical circumstances involved.*

### MILD STEEL

### Freedom from Defects

**201** (*a*) The minus tolerance in the thickness of plates and sections from those given on the approved plans is not to exceed 2 per cent. For plates below 25 mm. in thickness a plate edge thinning up to 0,5 mm. may be accepted if the average thickness of the plate is within the above minus tolerance limit.

The general standard as laid down by the Rules is to be maintained.

(*b*) The steel is to be reasonably free from segregations, surface flaws and non-metallic inclusions. The finished material is to be free from cracks and lamination. It shall also have a workmanlike finish, and must not have been hammer dressed.

(*c*) Surface defects may be removed by grinding, provided that the thickness is in no place reduced to less than 93 per cent of the nominal thickness but in no case by more than 3 mm. The extent of such repairs shall be agreed in each case with the Surveyors, and the repairs shall be carried out under the Surveyors' supervision unless otherwise agreed.

(*d*) Surface defects which cannot be dealt with as above may be repaired by chipping or grinding followed by welding, subject to the Surveyors' consent and under their supervision, provided:—

(i) that after removal of the defect, and before welding, the thickness of the item is in no place reduced by more than 20 per cent,

(ii) that the welding is carried out by an approved procedure, by competent operators with approved electrodes, and that the welding is ground smooth to the correct nominal thickness,

(iii) that subsequent to the finish grinding, the piece may be required to be normalised or otherwise heat treated at the Surveyors' discretion. Re-normalising will always be required if the piece has been normalised before the repair.

### Distinguishing Marks

**202** The entire marking (*see* P 105) is to be surrounded by a clear mark in paint of the following distinctive colours:—

| | | |
|---|---|---|
| Grade A steel | ... ... | white |
| Grade B steel | ... ... | green |
| Grade C steel | ... ... | blue |
| Grade D steel | ... ... | red |
| Grade E steel | ... ... | yellow |

Where the name of the steelworks is embossed on finished sections, only the Society's brand and items (i), (iii) and (iv) of P 105 need be surrounded by paint in appropriate colour.

### Standard Tensile Test Piece

**203** This piece shall have a rectangular cross-section with thickness equal to that of the material from which it is cut and a width of 25 mm. with a length between gauge marks of 200 mm. The parallel length shall not be less than 230 mm. The ends of the test piece may be increased in width to suit the grips of the machine, the transition between the different widths being made with a gentle curve.

The test pieces are to be cut with their lengths transverse to the principal direction of rolling except in the case of sections and narrow flats.

### Alternative Tensile Test Pieces

**204** Tensile test pieces of other dimensions or of cylindrical form may be used, provided that the elongations comply with 205, and provided that the cross-sectional area is not less than 161 square mm.

### Elongations in Tensile Test

**205** (*a*) The required minimum elongations, E, are indicated in the appropriate Rules for each grade of steel. (For ship steel *see* Table II.) These elongations are based on test pieces having gauge lengths equal to 5,65 times the square root of the cross-sectional area, or 5 times the diameter.

(*b*) For test pieces having gauge lengths bearing other relationships to the cross-sectional area, the equivalent elongations shall be calculated from the following formula:—

$$n = 2E\left(\frac{\sqrt{A}}{L}\right)^{0,40}$$

where n is the equivalent minimum elongation,

A is the actual cross-sectional area of the test piece,

L is the actual gauge length,

E is the specified minimum percentage elongation for test pieces in which

$L = 5,65\sqrt{A}$ (*see* 205 (*a*)).

NOTE.—A *and* L *may be in any consistent units.*

(*c*) For the "standard" test piece (*see* 203) the minimum percentage elongations shall not be less than the following:—

| *Thickness* | *Minimum Elongation* |
|---|---|
| 6 mm. ... ... ... ... | 0,68E |
| 30 mm. and over ... ... | 0,95E |

where E is the specified minimum as per 205 (*a*) above. The elongations for thicknesses between 6 mm. and 30 mm. may be obtained from the above by linear interpolation.

### Bend Tests

**206** The bend test shall consist in bending a strip or bar of the material until the ends are parallel to each other, and at a distance apart not exceeding three times the thickness or diameter of the strip or bar.

The strips shall have a width at least equal to the thickness but not less than 25 mm. and a thickness not less than that of the material tested, retaining the original rolled surfaces. The sharp edges of the strip may be removed by filing or machining, to a radius not exceeding $\frac{1}{10}$ of the thickness of the strip.

When the power of the available testing machine is insufficient to bend a test piece of the full thickness, this latter may be reduced by machining from one face or by turning down a round bar provided that the final thickness or diameter is not less than 25 mm. Strips shall be so bent that the original rolled surface is on the tension side.

The strips shall be cut with their lengths transverse to the principal direction of rolling except in the case of sections and narrow flats. The bending may be performed by pressure or by blows.

The bend test will be considered successful if no cracks or laminations appear.

### Impact Tests

**207** The impact test pieces (where specified) shall be of the Charpy V-notch type, 10 mm. square in cross-section, 55 mm. long, and having in the centre of the length of one face a perpendicular V-notch with an included angle of 45°, a depth of 2 mm. and a root radius of 0,25 mm. The specimens are to be accurately machined to the tolerances given in Table 1 and to a good finish. The prescribed dimensions are to be carefully and systematically checked. The test pieces shall be cut with their longitudinal axes parallel to the final direction of rolling of the material. The notch shall be cut in a face of the test piece which was originally perpendicular to the rolled surface.

TABLE I
DIMENSIONS AND TOLERANCES FOR CHARPY V-NOTCH TEST PIECES

| Dimensions | Nominal Dimension | Tolerance |
|---|---|---|
| Length ... ... ... | 55 mm. | ±0,60 mm. |
| Width ... ... ... | 10 mm. | ±0,11 mm. |
| Thickness ... ... ... | 10 mm. | ±0,11 mm. |
| Angle of notch ... ... | 45° | ±2° |
| Depth below notch ... | 8 mm. | ±0,11 mm. |
| Root radius ... ... ... | 0,25mm. | ±0,025 mm. |
| Distance of notch from end of test piece ... ... | 27,5 mm. | ±0,42 mm. |
| Angle between plane of symmetry of notch and longitudinal axis of test piece | 90° | ±2° |

The position of the notch shall not be nearer than 25 mm. to a flame-cut or sheared edge.

In the case of sections, the test pieces are to be cut from the thickest part.

The tests are to be carried out with the test pieces at a temperature carefully controlled to within $\pm 1°$ C. of the required temperature, on a Charpy impact machine of approved type installed in an approved manner having a gap of 40 mm., a striking velocity between 4,5 and 6 metres per second, and a striking energy of not less than 15 kilogramme metres. The angle of the striking edge of the pendulum is to be 30° with the edge rounded to a radius not exceeding 2 mm. The machine is to be periodically checked and calibrated on the lines indicated in paragraph P 111.

### Alternative Types of Test

**208** Other alternative types of test may be substituted for the Charpy V-notch impact test provided that equivalent standards of notch ductility can be established to the satisfaction of the Society.

### Number of Tensile Tests

**209** For each batch presented, one tensile test shall be made from one piece rolled from each cast unless the weight of finished material is greater than 40000 kgs. in which case one extra test shall be made from each 40000 kgs. or fraction thereof. Additional tests are to be made for every variation of 5 mm. in the thicknesses of pieces from the same cast.

### Number of Bend Tests

**210** One bend test is to be made from each piece rolled, except that one bend test only need be made from every two pieces having a finished weight of less than 2000 kgs. each, provided they are from the same cast.

### Number of Impact Tests (where required)

**211** Unless otherwise specified for a particular grade of steel, at least one piece is to be selected for impact testing from the thickest batch from each cast, unless the weight of finished material rolled from the cast is greater than 40000 kgs. in which case one extra test will be made from a different piece from each 40000 kgs. or fraction thereof, provided that the same procedures have been used in manufacture.

When plates of different widths are included in batches of the same thickness the widest plate is to be preferred for testing.

From each piece so selected, three impact tests as described in 207 shall be carried out. The average values obtained from these tests shall comply with the requirements. If, however, the average obtained fails to comply by an amount not exceeding 15 per cent of the required value, three additional test pieces from the same sample may be tested, and the results added to those previously obtained to form a new average, which must comply with the requirements.

### Definitions

**212** The term "piece" is to be understood to mean the rolled product from a single slab or from a single ingot if this is rolled directly into plates, bars or sections. The term "item" means any single plate, bar or section as delivered. The term "test piece" where it occurs means the sample of material which is actually tested.

### Additional Tests before Rejection

**213** (*a*) When the tensile or bend tests on the first piece selected in accordance with 209 and 210 fail to meet the requirements, two further tests of the same kind may be made from the same piece. If both these additional tests are satisfactory the piece and the remaining pieces from the same cast may be accepted.

(*b*) If the additional tests referred to in (*a*) are unsatisfactory the piece is to be rejected, but the remaining material from the same cast may be accepted provided that two of the remaining pieces selected in the same way are tested with satisfactory results.

(*c*) If the impact tests, carried out in accordance with 211 on the first piece selected, fail to meet the requirements the piece is to be rejected, but the remaining material from the same cast may be accepted provided that two of the remaining pieces, selected in the same way, are tested in the same way with satisfactory results.

(*d*) If any test piece fails because of faulty preparation or (in the case of a tensile test) because of fracturing outside the middle half of the gauge length, the defective test piece may at the Surveyor's discretion be discarded and replaced by an additional test piece from the same piece.

(*e*) At the option of the steelmakers, rejected material may be re-submitted after heat treatment or re-heat treatment or may be re-submitted as another grade of steel, and may then be accepted provided that the required tests are satisfactory.

### Position of Samples for Testing

**214** Except where otherwise specially agreed, the samples taken from the rolled material for the preparation of test pieces are to be cut from the end of the piece corresponding to the top end of the ingot. When the axis of the ingot is transverse to the length of the piece, either end may be selected but the sample should preferably be taken near to the edge corresponding to the top of the ingot.

TABLE II

| GRADE | A | B | C | D | E |
|---|---|---|---|---|---|
| 1. METHOD OF MANUFACTURE | As P 101 | As P 101 | Process to be specially approved | Process to be specially approved | Process to be specially approved |
| 2. DEOXIDATION | Any method. (For rimmed steel see Note 1) | Any method except rimmed steel | Fully killed, fine grain practice (Aluminium treated) | Any method except rimmed steel | Fully killed, fine grain practice (Aluminium treated) |
| 3. AUSTENITIC GRAIN SIZE (McQuaid-Ehn method ASTM scale (*See* P 217) | — | — | 5 or finer To be determined on each charge (*see* Note 4) | — | 5 or finer To be determined on each charge |
| 4. CHEMICAL COMPOSITION (ladle analysis) | | | | | |
| Carbon ... ... | *See* Note 2 | 0,21% max. | 0,23% max. } Note | 0,21% max. } Note | 0,18% max. } Note |
| Manganese ... | *See* Note 2 | 0,80% min. } *See* Notes 3 & 5 | 0,60% to 1,40% } 5 | 0,60% to 1,40% } 5 | 0,70% to 1,50% } 5 |
| Silicon ... ... | — | — | 0,15% to 0,30% | 0,35% max. | 0,10% to 0,35% |
| Sulphur ... ... | 0,05% max. | 0,05% max. | 0,05% max. | 0,05% max. | 0,05% max. |
| Phosphorus ... | 0,05% max. | 0,05% max. | 0,05% max. | 0,05% max. | 0,05% max. |
| 5. TENSILE TEST | | | | | |
| Tensile strength, kg./mm.$^2$ ... (*See* P 111) | 41 to 50 | 41 to 50 | 41 to 50 | 41 to 50 | 41 to 50 |
| Elongation E.% on $L=5{,}65\sqrt{A}$ ... (*See* P 205) | 22% | 22% | 22% | 22% | 22% |
| 6. IMPACT TEST | | | | | |
| Temperature ... | — | — | — | 0° C. | —10° C. |
| Energy ... ... | — | — | — | 35 ft. lbs. min. or 4,84 k.gm. min. | 45 ft. lbs. min. or 6,22 k.gm. min. Every plate to be tested |
| 7. BEND TEST | As P 206 | As P 206 | As P 206 | As P 206 | As P 206 |
| 8. HEAT TREATMENT | *See* P 215 | *See* P 215 | Normalised over 33 mm. thick | *See* P 215 | Normalised |

**NOTES.—TABLE II**

1. For Grade A, rimming steel may be accepted up to 12,5 mm. thick inclusive, provided that it is stated on the mill sheets to be rimming steel and is not excluded by the purchaser's order.

2. For Grade A in thicknesses over 12,5 mm. the manganese content shall not be less than 2,5 times the carbon content.

3. For Grade B, when the silicon content is 0,15 per cent or more (killed steel) the minimum manganese content may be reduced to 0,60 per cent.

4. For Grade C the determination of grain size may be alternatively substituted by impact tests as required for Grade D.

5. For Grades B, C, D and E, the sum of carbon content plus $\frac{1}{6}$ of the manganese content shall not exceed 0,40 per cent.

6. For use of Grade C in lieu of Grade D (*see* D 103).

### Heat Treatment

**215** Unless otherwise specified, or required by the conditions of approval of the process, the material may be presented in the "as rolled" or heat treated condition at the maker's option, subject to full compliance with the remainder of these Rules, and provided that the material which is presented in the normalised or otherwise heat treated condition is to be tested separately from material presented in the "as rolled" condition, even when all such material is from the same cast.

The sample of material from which test pieces are cut must be heat treated together with and in the same way as the material presented. Test specimens may not be separately heat treated in any way.

### Chemical Analysis

**216** The chemical composition shall be determined by the makers in an adequately equipped and competently staffed laboratory on samples taken from each ladle of each cast. The maker's analysis will be accepted subject to occasional checks if required by the Surveyors.

### Austenitic Grain Size

**217** The austenitic grain size where required is to be determined by the McQuaid-Ehn method from samples representative of each ladle of each cast. The grain size numbers indicated refer to the ASTM scale described in ASTM E112–58T, or any later ASTM specification which may supersede it.

### Applications

**218** For information regarding requirements for the application of the different grades of steel, reference should be made to the following paragraphs:—

D 103, D 3104, D 3105, D 3106, D 3710, D 3711, D 4010, D 4011, Sections D 70, D 71 and D 72.

## HIGHER TENSILE STEEL

*The following paragraphs do not constitute a complete specification for higher tensile steel for hull construction but are intended for the guidance of Steelmakers and Shipbuilders.*

### General

**219** The requirements of P 1 and P 2 are to be complied with so far as they are applicable and as amended in the following paragraphs.

### Approval of Steel

**220** Full details of the method of manufacture including chemical composition, heat treatment and mechanical properties are to be submitted for approval. If considered necessary, tests are to be made on samples of steel manufactured in accordance with the proposed specification.

The steel should be capable of being fabricated and welded under shipyard conditions. Low hydrogen electrodes should be used, and if the thickness exceeds 25 mm. preheating may be necessary.

### Number of Tests

**221** At least one tensile test, one bend test and one set of three Charpy V-notch tests are to be made on each piece (*see* 212) presented for acceptance. (These requirements may be reconsidered after the intial stages of production.)

### Mechanical Properties

**222** (*a*) The tensile strength is to be within the limits given in the approved specification. The specified range between maximum and minimum is not to exceed 12,6 kg. per mm.$^2$.

(*b*) The upper yield stress or 0,5% proof stress is to be within the limits given in the approved specification and, in any particular test, is not to exceed 80% of the actual tensile strength. (*See also* 223 and 224.)

(*c*) The elongation in the tensile test shall be in accordance with the approved specification.

(*d*) Bend tests. The test pieces are to be bent cold without fracture. The diameter of the former and the angle of bend are to comply with the approved specification.

(*e*) The Charpy V-notch impact values are to be determined in accordance with 207 and 211. The percentage crystallinity, based on the original area, is to be recorded for information.

| GRADE | TEST TEMP. | MINIMUM ENERGY kg. m. |
|---|---|---|
| AH (For Grade A application) | 0°C. | 2,765 (*see* Note) |
| DH (For Grade D application) | 0°C. | $4{,}84 \times \frac{1}{\sqrt{k}}$ |
| EH (For Grade E application) | −10°C. | $6{,}22 \times \frac{1}{\sqrt{k}}$ |

where $k = \frac{70{,}9}{Y + U}$

and Y = specified minimum upper yield stress or 0,5% proof stress in kg. per mm.$^2$ or 0,7 U whichever is the less.

U = specified minimum tensile strength plus one half of the specified range, in kg. per mm.$^2$

NOTE.—The necessity for impact testing of Grade AH plates will depend on the particular method of manufacture and will be decided when the specification is submitted for approval.

### Determination of Upper Yield Stress

**223** This is considered as the stress at which, under moderately fast rates of loading, a sudden increase occurs in the gauge length and may be observed either by:—

(1) measurement with dividers

(2) a distinct drop in the testing machine lever

(3) a marked hesitation or fall back in the movement of the pointer of the indicating machine.

In cases of doubt the upper yield stress shall be determined by means of dividers or an extensometer, and shall be taken as the stress corresponding to an increase of at least 0,5% of the original gauge length.

For materials which do not show a well defined yield point the 0,5% proof stress should be determined.

### Determination of 0,5% Proof Stress

**224** The 0,5% proof stress shall be determined from a stress strain diagram on which a line is drawn parallel to the straight portion and distant from it by an amount representing an increase in strain of 0,5%. The point at which the line cuts the curve represents the 0,5% proof stress.

### Surface Inspection

**225** Attention is drawn to P 103 and it is recommended that both surfaces of all plates be carefully inspected at the steelworks and the edges examined for laminations or other defects.

### Freedom from Defects

**226** If surface defects are repaired by welding (*see* 201 (*c*)) the procedure shall be appropriate to the steel and a suitable heat treatment will be required.

### Marking

**227** Distinguishing marks are to be as required by P 105 and 202 but the grade mark is to be followed by a letter "H" (as in 222 (*e*)). A large letter "H" is also to be painted near the brand marking in the appropriate colour given in 202.

## Section 3

## STEEL FOR BOILERS, PRESSURE VESSELS AND WELDED MACHINERY STRUCTURES

### General

**301** Plates, sections and bars intended for marine boilers, pressure vessels and welded machinery structures are to comply with the requirements and tests of this section. The requirements are not applicable to pressure vessels containing radio-active materials or gases.

### Orders for Materials

**302** The order should specify the required type, grade and condition of the material, and the purpose for which it is intended.

### Process of Manufacture

**303** The steel is to be made at an Approved Works by the open hearth, electric furnace or other approved process. The melting shop practice is to be such as to minimise the included non-metallic contents of the steels. Ingots are to be cast in chilled moulds.

Carbon and carbon-manganese steels are to be killed or semi-killed. Rimmed steels are not acceptable.

Sufficient discard is to be made from the top and bottom of each ingot to ensure soundness in the portion used for plates, bars and sections. Periodically and at the Surveyor's discretion sulphur prints or other suitable proving tests may be required from the rolled material to demonstrate that this has been fulfilled.

The size of ingot is to be proportioned to the thickness of the plate, section or bar in order that the amount of rolling work is adequate to ensure a satisfactory steel structure in the finished product.

### Freedom from Defects

**304** The steel is to be free from harmful segregations, flaws and laminations. It is to have a workmanlike finish and must not have been hammer dressed. Material despatched from the steel works must not have been repaired by welding.

Slight scale or shell may be removed by careful chipping, filing, grinding, or sand- or shot-blasting. Such rectification must be completed to the satisfaction of the Surveyor.

## STEEL PLATES

### Carbon and Carbon-Manganese Steel Plates

**305** Provision is made for carbon and carbon-manganese steel plates of thicknesses up to 150 mm. and having tensile strengths ranging from 38 to 60 kg. per mm.$^2$ For purposes of constructional applications and test requirements the steels are graded according to tensile strength as listed in Table I.

TABLE I

MECHANICAL PROPERTIES OF PLATES, SECTIONS AND BARS

*Material—Carbon and Carbon-Manganese Steels*

| Grade | Tensile Strength kg. per mm.² | | Minimum Percentage Elongation on Gauge Length | | | Bend Test Max. Radius of Former |
|---|---|---|---|---|---|---|
| | Min. | Max. | 200 mm. | $4\sqrt{A}$ | $5{,}65\sqrt{A}$ | |
| 1 | 38 | 44 | 25* | 30 | 26 | 1 t |
| 2 | 41 | 47† | 23* | 29 | 25 | 1 t |
| 3 | 44 | 50† | 20* | 27 | 23 | $1\frac{1}{2}$t |
| 4 | 47 | 54† | 18* | 24 | 21 | $1\frac{1}{2}$t |
| 5 | 50 | 60 | 17* | 22 | 19 | $1\frac{3}{4}$t |

* For plates under 9,5 mm. in thickness the minimum percentage elongation values may be reduced by 3.

† For individual plates exceeding 10000 kg. in weight the maximum tensile strength may be increased by 3,2 kg. per mm.²

A is the area of the cross-section of the test piece.

t is the thickness or diameter of the test piece.

NOTE.—When these steels are used for welded constructions, attention should be given to J 2203 and J 2214. These requirements are particularly important for Grades 4 and 5 steels.

### Chemical Composition of Carbon Steels

**306** (*a*) Ladle analyses of carbon steels are to comply with the following ranges of chemical composition:—

| | |
|---|---|
| Carbon | 0,23% max. * for Steels of Grades 1 and 2 |
| | 0,26% ,, † ,, ,, ,, Grade 3 |
| | 0,30% ,, ‡ ,, ,, ,, Grades 4 and 5 |
| Silicon | 0,15% to 0,35% (applicable to killed steels only) |
| Manganese | 0,50% to 1,00% |
| Sulphur | 0,050% max. |
| Phosphorus | 0,050% max. |

* For plates over 75 mm. thick the carbon content may be increased to 0,25% max.

† For plates over 75 mm. thick the carbon content may be increased to 0,28% max.

‡ For plates over 75 mm. thick the carbon content may be increased to 0,32% max.

Residual elements are to be maintained as low as possible and should not exceed the following:—

| | |
|---|---|
| Copper ... ... | 0,30% |
| Nickel ... ... | 0,30% |
| Chromium ... ... | 0,25% |
| Molybdenum ... | 0,10% |
| Total Residuals ... | 0,70% |

### Chemical Composition of Carbon-Manganese Steels

(*b*) Ladle analyses of carbon-manganese steels are to comply with the following range of composition:—

| | |
|---|---|
| Carbon ... ... | 0,20% max. |
| Manganese ... | 1,60% max. |
| Silicon ... ... | 0,15% to 0,50% (for killed steels only) |
| Sulphur ... ... | 0,050% max. |
| Phosphorus ... | 0,050% max. |

The residual elements are to comply with the limitations given in 306(a) for the composition of carbon steels.

In addition to the above, for carbon-manganese steels the sum of the carbon percentage and one sixth of the manganese percentage is not to exceed:—

0,40 for Steels of Grades 1 and 2
0,42 for Steels of Grade 3
0,44 for Steels of Grades 4 and 5

### Low Alloy Steel Plates

(*c*) Where it is proposed to use low alloy steels, particulars of the manufacture, chemical composition, mechanical properties and heat treatment are to be submitted for approval. For high temperature applications typical long-term creep and rupture data, scaling and corrosion resistance at the operating temperatures are to be submitted if required. These steels will be tested and accepted on the basis of the approved specification and such other tests as may be considered necessary.

### Statement of Analysis

(*d*) The steelmaker is to provide a statement giving the ladle analysis of the steel for each plate. For a carbon or a carbon-manganese steel this should include the carbon, manganese, silicon, sulphur and phosphorus contents. For low alloy steels the analysis should also include the principal alloying elements.

Residual elements need not be stated in all cases but these may be required for periodical check by the Surveyor in attendance at the steelworks.

### Steels for Boilers and other Pressure Vessels

**307** The grades of carbon and carbon-manganese steel plates are restricted to the applications in boiler and pressure vessel construction as listed in Table II.

Killed steel is to be used for Class 1 fusion welded and Class 1 forged welded pressure vessels.

Silicon killed steel is to be used for pressure vessels where the operating metal temperatures exceed 400° C.

TABLE II

| Application | Grade of Steel |
|---|---|
| Welded Pressure Vessels Class 1 ... | 1 2 3 4 5 |
| ,, ,, ,, ,, 2A, 2B and 3 ... ... ... ... | 1 2 3 |
| Shells of all-riveted boilers ... ... | 2 3 4 |
| Shells of riveted boilers with welded compensating rings and attachments ... ... ... ... | 2 3 |
| Boiler furnaces, combustion chambers and flanged plates ... ... | 2 |
| Forge welded pressure vessels ... | 1 2 |

Steel intended for pressure vessels operating at low metal temperatures should be fine grained and may be aluminium killed; proposed applications are to be submitted for approval.

### Steels for Welded Engine Structures

**308** Grades 1 and 2 carbon and carbon-manganese semi-killed steels are suitable for welded engine bedplates and similar engine structures and are acceptable as meeting the requirements of H 903.

### Heat Treatment of Plates

**309** Grades 1, 2 and 3 carbon and carbon-manganese steel plates exceeding 44 mm. thickness and all thicknesses of Grades 4 and 5 plates are to be normalised. The steelmaker is to provide a statement giving the heat treatment condition of each plate.

### Hot Spun, Bent or Pressed Plates

**310** When plates are hot formed in the production of cylindrical shells and dished ends for boilers and other pressure vessels, the fabricator must either demonstrate that the process is so controlled as to ensure that the finished steel has a normalised structure or normalise the parts on completion of the operation.

For low alloy steels and Grades 4 and 5 carbon and carbon-manganese steels check tensile tests are required from each hot formed (and where applicable heat treated) cylindrical shell and dished end. Test pieces are to be selected from material which is to be discarded from the hot formed part. Providing the Surveyor's consent is obtained, a curved test plate may be cold flattened to obtain a suitable test piece.

Alternative procedures to the above may be submitted for special consideration.

### Number of Tests—Plates

**311** At least one set of mechanical tests comprising a tensile and a bend test is to be made on the material of each plate as rolled. One set of test pieces is to be selected from the material at the quarter-width of each plate weighing less than 2500 kg. For each heavier plate, one set of test pieces is required from the quarter-width of both ends, except where the material will be used for the fabrication of welded engine structures, when only one set of tests is required. The test pieces are to be cut transverse to the principal direction of rolling.

Where plates are normalised at the steelworks the test material is not to be removed from a plate until the heat treatment is completed.

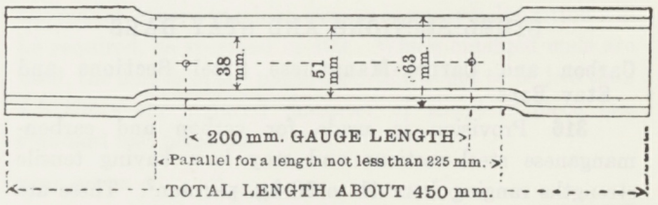
If specified by a manufacturer of fusion welded boilers or pressure vessels, test material cut from plates may be stress relief heat treated before machining the test pieces. This heat treatment is to be in accordance with J 1925.

NOTE.—Although this procedure may provide for some loss of tensile strength of the plates due to stress relief heat treatment, final acceptance is based on the actual tensile strength of the cross weld tensile test piece detailed in J 1920.

### Tensile Test Pieces for Plates

**312** Wherever practicable the rolled surfaces are to be retained on two opposite sides of the test piece. When the elongation is measured on a standard test piece having a gauge length of 200 mm., for material more than 22 mm. in thickness the width of the test piece between the gauge points is not to exceed 38 mm.; for material 22 mm. to 9,5 mm. in thickness, inclusive, the width is not to exceed 51 mm.; for material less than 9,5 mm. in thickness the width is not to exceed 63 mm. In other respects the test pieces are to conform generally to the standard test piece A.

TEST PIECE A




For Thicknesses over 22 mm.:— Maximum width allowed = 38 mm.

For Thicknesses 9,5 mm. to 22 mm.:— Maximum width allowed = 51 mm.

For Thicknesses under 9,5 mm.:— Maximum width allowed = 63 mm.

Any straightening of the test pieces which may be required is to be done cold. For plates over 38 mm. in thickness a round proportional tensile test piece may be used as an alternative provided the cross-sectional area is not less than 3,2 cm.$^2$ (See also 305, Table I).

For check tensile tests on parts hot formed from plates, any suitable standard test piece is acceptable providing the cross-sectional area is not less than 1,6 cm.$^2$

### Bend Test Pieces for Plates

**313** Bend test pieces if practicable are to be full plate thickness and not less than 38 mm. in width. For thick plates two bend test pieces, 38 mm. wide by 25 mm. thick can be used as an alternative, providing the tension surfaces of the two pieces are parts of the original surfaces of the plate. Bend test pieces may be prepared by shearing or machining and the rough edges may be removed with a file before testing.

### Mechanical Properties—Plates

**314** The tensile properties determined on each test and check test piece are to comply with the requirements of Table I for the particular grade of steel.

Each bend test piece is to withstand cold bending through 180° without fracture over a former with a maximum radius as given in Table I for the grade of steel.

### Additional Tests before Rejection

**315** Where either the tensile test or bend test, or both, fail, and the Surveyor considers the fractured test piece or test pieces, or the results obtained therefrom, do not fairly represent the quality of the plate, duplicates of the test or tests which failed are to be made if requested by the maker. In such cases the quality of the plate is to be judged by the results of the duplicate test or tests and not by the original test or tests which failed. If any one of the retests fails the plate is unacceptable.

However, at the discretion of the Surveyor and if requested by the maker, the plate may be heat treated and offered for further testing. In this connection the results of the previous tests are to be disregarded.

## STEEL SECTIONS AND STAY BARS

### Carbon and Carbon-Manganese Steel Sections and Stay Bars

**316** Provision is made for carbon and carbon-manganese steel sections and stay bars having tensile strengths ranging from 41 to 50 kg. per mm$^2$. These are graded on mechanical properties as follows:—

| *Bar or Section* | *Grade in Table I* |
|---|---|
| Angles, Tees and other Sections | 2 and 3 |
| Longitudinal Stay Bars | 2 and 3 |
| Combustion Chamber Stay Bars | 2 |

Where any of these sections or bars is to be welded to the pressure parts of a boiler or pressure vessel the composition of the grade of steel is to comply with the requirements of 306(a) or 306(b).

### Other Grades or Types of Steel

**317** Where it is proposed to use either a steel of a grade other than those permitted in 316 or a low alloy steel, particulars of the chemical composition, mechanical properties and heat treatment are to be submitted for approval.

### Number of Tests—Sections and Bars

**318** For each size of section or bar rolled from the same charge the numbers of tensile test pieces required are as undernoted:—

| | | |
|---|---|---|
| Sections and Bars over 44 mm. diameter | 8 or less | 1 tensile test |
| | 9 to 29 | 2 tensile tests |
| | 30 or over | 1 tensile test for 15 or part of 15 |
| Bars 44 mm. diameter and under | 20 or less | 1 tensile test |
| | 21 to 99 | 2 tensile tests |
| | 100 or over | 1 tensile test per 50 or part of 50 |

A bend test piece is to be taken from each section as rolled. For each tensile test required from bar material, a bend test is also to be made.

### Tensile and Bend Test Pieces for Sections and Bars

**319** For sections the tensile test pieces are to be prepared in accordance with the requirements of 312 and 313. For bars, tensile test pieces may be either the full section as rolled or may be machined to a convenient size, provided the area of the reduced portion is not less than 3,2 cm$^2$. Any of the gauge lengths given in Table I may be used.

Bend tests from sections are to be prepared and tested in accordance with the requirements for plate material. Bars may be tested on either the full section as rolled or on a section reduced by machining to a diameter of not less than 25 mm.

### Mechanical Properties—Sections and Bars

**320** The tensile properties determined on each test piece are to comply with the requirements of Table I for the particular grade of steel or approved specification.

Each bend test piece is to withstand cold bending through an angle of 180° without fracture over a former with a maximum radius as given in Table I for the grade of steel or as otherwise approved.

### Additional Tests before Rejection

**321** Where either the tensile or bend test, or both, fail, and the Surveyor considers the fractured test pieces or the results obtained therefrom do not fairly represent the quality of the section(s) or bar(s), duplicates of the test or tests which failed are to be made if requested by the maker. For a single section or bar the pieces for retest are to be cut adjacent to the original test material. For batches, one of the pieces for retest is to be taken from that position and the other from a different section or bar in the batch.

If any one retest fails the sections or bars are unacceptable but at the discretion of the Surveyor and on request of the maker either each item in a batch may be tested separately or the items may be heat treated and offered for further testing.

### Seamless Receivers

**322** In the case of seamless receivers, the rules for material will be the same as for boiler shells, but the permissible extension may be 2 per cent less than that required for boiler plates.

The thicknesses of seamless receivers are to be verified by the Surveyor before the ends are closed in, and at this time the Surveyor is to select and mark the test pieces required from either of the open ends of the tube.

The test pieces are to be subjected to the same heat treatment as that given to the receivers.

## Section 4

## RIVET BARS AND MANUFACTURED RIVETS

### Testing of Material

**401** All material from which rivets are manufactured is to be tested.

Rivets are not to be manufactured from steel or ingot iron bars in which the sulphur segregates and other non-metallic substances are concentrated in the core. To ensure this, a sulphur print is to be taken from the material of each charge, and where the weight of bars as rolled from one charge exceeds 10000 kg., additional sulphur prints may be taken.

### Number of Tests

**402** In the case of steel bars, one tensile test piece is to be taken from each charge used for rivet bars; but where the weight of bars as rolled from one charge exceeds 10000 kg., an additional tensile test is to be made from each further 10000 kg. or portion thereof.

**403** In the case of wrought iron bars, two tensile tests shall be taken from every 3000 kg. or portion thereof in each batch of any order presented for inspection, except that, in the case of lots of 1000 kg. or less, one tensile test shall be accepted.

**404** In the case of ingot iron bars, one tensile test piece is to be taken from each charge used for rivet bars; but where the weight of bars as rolled from one charge exceeds 10000 kg., an additional tensile test is to be made from each further 10000 kg. or portion thereof.

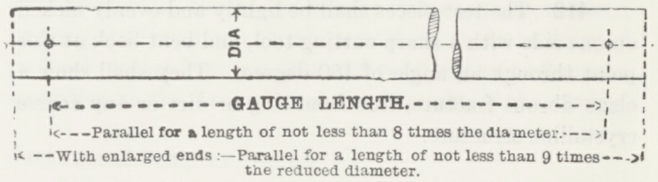
**405** For rivet bars of steel or ingot iron one dump test is to be made for each tensile test.

### Tensile Test Pieces

**406** Bars may be tested full size as rolled, or they may be turned down to a convenient size, and if tested 25 mm. in diameter, or under, the test piece is to have a gauge length of eight times the diameter. Where enlarged ends are used, the length of the parallel portion is not to be less than nine times the reduced diameter of the test piece (*see* standard test piece B).

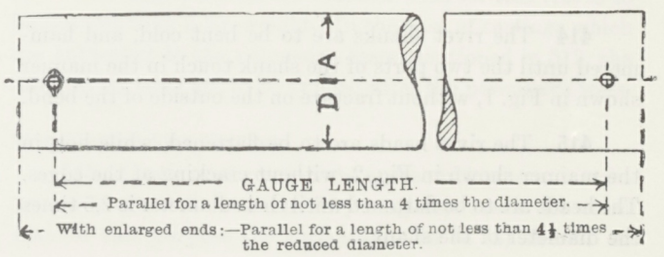
The sectional area of the test piece is not to be less than 160 mm$^2$.

TEST PIECE B




**407** Where bars are above 25 mm. diameter, and are tested full size as rolled, or have been turned down and the resulting test piece is above 25 mm. diameter, a gauge length of four times the diameter may be used if preferred by the manufacturer, in which case an increased elongation will be required, as specified in 409. Where enlarged ends are used, the length of the parallel portion is not to be less than 4,5 times the reduced diameter of the test piece (*see* standard test piece C).

TEST PIECE C



### Straightening of Test Pieces

**408** Any straightening of test pieces which may be required is to be done cold.

### Tensile Tests

**409** The tensile strengths and elongations of rivet bars are to be within the following limits:—

| Material | Tensile Strength Kg. per mm². | Minimum Elongation | |
|---|---|---|---|
| | | Gauge Length | |
| | | 4 × d (Test piece C) | 8 × d (Test piece B) |
| Steel | 41—47 | 30% | 25% |
| Wrought Iron | 33—39 | — | 22% |
| Ingot Iron | 33—39 | 30% | 25% |

### Dump Test

**410** Short lengths, equal to twice their diameter, cut from the rivet bars shall, when cold, withstand without fracture being compressed to half their length.

### Nicked Bend Tests

**411** In the case of wrought iron bars one nicked bend test shall be taken from each 3000 kg. of material or portion thereof in each batch of any order presented for inspection.

**412** The test pieces shall be lightly and evenly nicked on one side with a sharp cutting tool, and bent back at this point through an angle of 180 degrees. They shall show a clean fibrous fracture, free from slag or dirt or any coarse crystalline structure.

### Manufactured Rivets

**413** Rivets selected by the Surveyor from the bulk are to withstand the tests described in 414 to 416.

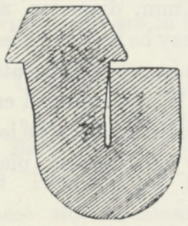


FIG. 1

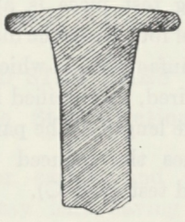


FIG. 2

**414** The rivet shanks are to be bent cold, and hammered until the two parts of the shank touch in the manner shown in Fig. 1, without fracture on the outside of the bend.

**415** The rivet heads are to be flattened, while hot, in the manner shown in Fig. 2, without cracking at the edges. The heads are to be flattened until their diameter is 2,5 times the diameter of the shank.

**416** In the case of steel or ingot iron rivets, samples are to be selected by the Surveyor for examination by means of sulphur prints, to ensure that the material is free from marked central segregation.

## Section 5

## STEEL CASTINGS

### Process of Manufacture

**501** Steel for castings is to be made by the acid open hearth, basic open hearth or electric furnace process or by such other process as may be approved by the Committee and is to contain not more than 0,05 per cent sulphur or 0,05 per cent phosphorus.

### Heat Treatment

**502** The heat treatment of castings is to be carried out in a properly constructed furnace having adequate means of temperature control and the furnace must permit of the whole casting being uniformly heated to the necessary temperature as follows:—

Castings are to be fully annealed within a temperature range of 850° C. to 930° C., the temperature depending on composition.

Crank webs and combined crank web and pin casting after rough machining are to be stress relieved within a temperature range of 630° C. to 650° C., followed by furnace cooling. Other important engine components which in service are subject to dynamic loading are to be similarly heat treated if required.

Where it is desired to adopt other heat treatments, particulars are to be submitted for consideration.

### Testing and Inspection

**503** The tests and inspections described in this Section are to be made, preferably at the place of manufacture prior to despatch, but in the event of any casting proving unsatisfactory in the course of preparation or erection, such casting is to be rejected notwithstanding any previous certificate of satisfactory testing.

**504** The tensile strength and ductility are to be determined from standard test pieces, (*see* 507) which are to be prepared from pieces cast on the casting. These pieces are not to be cut or partially cut from the castings until the heat treatment of such castings has been completed, nor until they have been stamped by the Surveyor. The test pieces are to be stamped by the Surveyor after the heat treatment. All test pieces are to be selected by the Surveyor and tested in his presence, and he is to satisfy himself that the conditions herein described are fulfilled.

**505** Where the castings are to be used for purposes for which cast iron is ordinarily employed they need not be submitted to tensile and bend tests, but they are to be submitted to the hammering tests specified in 514.

### Number of Tests

**506** At least one tensile test and one cold bend test are to be taken from each casting. In castings of complex design, referred to in 513, at least two tensile tests and two cold bend tests are to be taken. Where a casting is made from more than one charge of steel, at least four tensile tests and four cold bend tests are to be made upon pieces cast as far apart as possible, some test pieces being taken from as near the top, and others from as near the bottom of the casting as practicable. Where a number of charges are all mixed in one ladle before casting they may be considered as a single charge.

### Dimensions of Tensile Test Pieces

**507** The standard tensile test pieces are to be turned so as to have a diameter of 14 mm. with a gauge length of 50 mm., or a diameter of 20 mm. with a gauge length of 75 mm., or a diameter of 25 mm. with a gauge length of 90 mm.

### Tensile Tests

**508** The tensile breaking strength determined from test pieces of standard dimensions is to be between the limits of 41 and 55 kg. per mm.$^2$ with an elongation of not less than 20 per cent measured on the standard test piece.

In the case of machinery parts such as boiler mountings, valve chests, and other important machinery castings, the tensile breaking strength is to be between the limits of 44 and 55 kg. per mm.$^2$, with a minimum elongation of 20 per cent measured on a standard test piece.

For cast steel crank webs or combined crank webs and pins, the tensile strength of the material is to be between the limits of 44 and 55 kg. per mm.$^2$ and the yield point of the material is to be not less than half the tensile strength. The sum of 0,635 times the tensile strength, in kg. per mm.$^2$, and the percentage elongation is to be not less than 57.

### Dimensions of Bend Test Pieces

**509** The bend test pieces are to be machined either to a rectangular section 25 mm. by 19 mm. with the edges rounded to a radius of 1,5 mm. or to a diameter of 25 mm.

### Bend Tests

**510** The bend test pieces are to withstand, without fracture, being bent cold as follows:—

For crank webs and combined crank webs and pins, through an angle of 180°, the internal radius of the bend being not greater than 19 mm.

For other castings, through an angle of 120°, the internal radius of the bend being not greater than 25 mm.

The bending may be performed either by pressure or by blows, and rectangular section test pieces are to be bent over the thinner section.

### Additional Tests before Rejection

**511** Where either the tensile test or the bend test, or both, fail, and the Surveyor considers the fractured test piece or test pieces, or the results obtained therefrom, do not fairly represent the quality of the casting, duplicates of the test or tests which failed are to be made if requested by the maker. In such cases the quality of the casting is to be judged by the result of the duplicate test or tests and not by the original test or tests which failed.

### Percussive Tests

**512** Stern frames cast in one piece are to be let fall on hard ground (excavations being made to take bosses and other projections) after being raised through an angle of 45 degrees. Stern frames cast in more than one piece, rudders, steering quadrants, crossheads and tillers, are to be dropped on hard ground from a height of from 2 metres to 3 metres according to the design, shape, and weight of the casting.

### Castings of Complex Design

**513** Castings of complex design which would be liable to be deformed if submitted to the drop or percussive test, may be exempt from this test provided two tensile tests and two cold bend tests are made upon pieces taken from positions as far apart as possible on each casting; one tensile test and one bend test should be taken from as near the top and the others from as near the bottom of the casting as practicable.

### Hammering Tests

**514** All castings are to be slung up and well hammered to satisfy the Surveyors that the casting is sound and without flaw. For large castings the hammer used for this test is to be not less than 3 kg. weight. In the case of castings which are subjected to the percussive tests mentioned in 512, the hammering tests are to be applied after the percussive tests.

### Non-Destructive Testing

**515** Castings of crank webs and combined crank webs and pins are to be examined by magnetic crack detection and for this purpose the surfaces are to be (*a*) cleaned or

pickled and coated with a suitable white paint or (*b*) machined or (*c*) smoothed by grinding as may be required by the Surveyors. The surfaces are not to be hammered, peened or treated in any way that would invalidate the examination.

In the case of other large castings, the Surveyor may request a supplementary examination either by radiography, ultrasonic or other approved methods of non-destructive testing in order to determine the soundness of the castings. The examination should be carried out at positions mutually agreed upon by the Surveyor and manufacturer where experience shows that cavities or contraction cracks are most likely to occur.

Where apparatus for non-destructive testing is not available at the foundry, the examination of crank webs and combined crank webs and pins by magnetic crack detection is to be carried out elsewhere, but in the case of other large castings, the Surveyor may request the soundness to be verified by drilling small holes. The Surveyor and manufacturers should agree on the location and depth of these holes, which are subsequently to be tapped and properly filled with a screwed plug.

### Branding

**516** Every casting, after it has withstood satisfactorily the prescribed tests, is to be clearly and distinctly marked by the Surveyor indicating that the casting has complied with the Society's requirements.

## Ferritic Steel Castings for Turbines

### Process of Manufacture

**517** Cast steel turbine cylinders and associated castings may be made from any of the types of steel shown in Table 1. Other suitable low alloy steels, with tensile strengths not exceeding 71 kg. per mm.$^2$, may be used provided details of the proposed composition, heat treatment and mechanical properties are submitted for consideration and approval.

The ladle analysis is to comply with the composition given in Table 1 or with the approved specification.

In all cases the steel used is to be made at an approved works by the open hearth or electric furnace process.

### Heat Treatment

**518** The castings are to be heat treated in properly constructed furnaces having adequate means of temperature control and the furnace must permit of the whole casting being uniformly heated to the necessary temperature.

All castings are to be fully annealed within a temperature range of 1560° F. (850° C.) to 1740° F. (950° C.), the temperature depending on the composition. Alloy steel castings are subsequently to be normalised followed by tempering at a temperature of 1110° F. (600° C.) to 1200° F. (650° C.), or as otherwise approved.

### Removal of Surplus Material

**519** Special precautions are to be taken to avoid damage to castings when any surplus metal is removed by flame cutting. Such metal should be removed before final heat treatment of the castings and the affected areas are to be subsequently dressed by grinding or chipping and grinding, and examined by a suitable magnetic crack detection method.

### Examination and Repair of Castings

**520** Castings are to be examined by the Surveyor on completion of the annealing operation. The surfaces may be pickled but must be suitably cleaned for examination. The surfaces are not to be extensively hammered, peened or treated in any way that may invalidate the inspection.

At changes of section, surfaces are to be smoothed by grinding or coated with a suitable white paint and examined by magnetic crack detection. The Surveyor may request a supplementary examination either by radiography, ultrasonic or other approved methods of non-destructive examination in order to determine the soundness of the

Table 1

| Type of Steel | Carbon | Carbon Manganese | ½% Mo. | 1 % Cr. ½ % Mo. |
|---|---|---|---|---|
| Carbon ... ... % | 0,25 max. | 0,25 max. | 0,25 max. | 0,25 max. |
| Manganese ... % | 0,5 to 1,0 | 1,0 to 1,5 | 0,5 to 1,0 | 0,5 to 0,8 |
| Silicon ... ... % | 0,15 to 0,5 | 0,15 to 0,5 | 0,15 to 0,5 | 0,15 to 0,5 |
| Sulphur ... ... % | 0,050 max. | 0,050 max. | 0,050 max. | 0,050 max. |
| Phosphorus ... % | 0,050 max. | 0,050 max. | 0,050 max. | 0,050 max. |
| Chromium ... % | — | — | — | 0,8 to 1,4 |
| Molybdenum ... % | — | — | 0,4 to 0,7 | 0,45 to 0,65 |

casting. The examination should be carried out at positions mutually agreed upon by the Surveyor and manufacturer, where experience shows that cavities or contraction cracks are most likely to occur.

When defects are found in a casting, the Surveyor is to satisfy himself whether the number and size of the defects are such that the casting can be efficiently repaired. If found repairable, the defects are to be removed to his satisfaction and in a form suitable for welding. Welding of the affected parts is to be undertaken by a procedure, the essential elements of which have been tested previously by the manufacturers and approved by the Surveyor. The welding is to be done under cover in positions free from draughts and adverse weather conditions by competent welders with adequate supervision. All welding is to be to the satisfaction of the Surveyors.

The castings are then to be stress relief heat treated at a temperature of not less than 1110° F. (600° C.). Where possible, however, low alloy steel castings are to be repaired by welding before normalising and tempering. On completion of welding and stress relief heat treatment, the welds and adjacent metal are to be smoothed and proved by magnetic crack detection. The stress relieving temperature is not to exceed the temperature at which a casting was previously tempered.

### Test Material

**521** Unless otherwise approved, test blocks are to be cast integral with the castings and are to be of sufficient size to provide specimens for mechanical tests. Test material is not to be detached from a casting until all heat treatments, other than stress relieving after rough machining, as required by H 421, are completed.

The test blocks are only to be flame cut from castings when the process neither damages the surfaces of the castings, nor affects the characteristics of the test material.

### Number of Tests

**522** At least one tensile and one bend test piece are to be taken from each casting.

### Mechanical Properties

**523** Tensile test pieces are to be of the round proportional type with a gauge length of $4\sqrt{A}$. The cross sectional area is not to be less than 1,6 cm$^2$.

The tensile strength of the steel is to be within the limits given in Table 2 or within the limits of the approved specification. In all cases the elongation is not to be less than 20 per cent and the reduction in area not less than 30 per cent.

TABLE 2

| Type of Steel | Range of Tensile Strength |
|---|---|
| Carbon ... ... ... | 44–55 kg. per mm.$^2$ |
| Carbon Manganese ... | 44–55 ,, ,, ,, ,, |
| ½% Mo. ... ... ... | 44–63 ,, ,, ,, ,, |
| 1% Cr. ½% Mo. ... ... | 47–71 ,, ,, ,, ,, |

**524** The bend test piece is to be machined to a diameter of 25 mm. or to a rectangular section 25 mm. by 19 mm. with the edges rounded to a radius of 1,5 mm.

The test piece is to withstand, without fracture, being bent cold through an angle of 120° over a former of radius not more than 25 mm. Bending may be performed either by pressure or by blows and is to be over the thinner section for rectangular section test pieces.

### Additional Tests before Rejection

**525** Where either the tensile test or bend test or both fail and the Surveyor considers that the results may not fairly represent the quality of the casting, two additional test pieces may be taken. If possible one is to be taken from the test block used for the original tests and the second from another test block. In such cases the quality of the casting is to be judged on the results of two retests and not on the results of the original tests which failed.

If the results of the mechanical tests and retests fail to meet the requirements of 523 and 524, the manufacturer may reheat-treat the casting provided the Surveyor's consent is obtained. Castings so treated are to be presented for further complete mechanical tests.

### Branding

**526** Every casting to be marked in accordance with 516.

## Section 6

## INGOT STEEL FORGINGS

### LARGE CARBON STEEL FORGINGS

### General

**601** These requirements apply to important ship and machinery components of wrought carbon steel and having a ruling section greater than 150 mm. Typical items are as follows:—

(a) Stern frames, "A" brackets, rudder stocks, main-pieces and arms and other important ship forgings.

(b) Crank and other shafting, forged slabs for crank webs, connecting rods, piston rods, crossheads and other important machinery forgings.

(c) Crank webs made from rolled slabs and straight shafts, rudder stocks, etc., made from rolled bar.

(*See* this Section for turbine rotors and subsequent Sections for seamless drums and gearing forgings.)

### Process of Manufacture

**602** The forgings are to be manufactured from killed steel made at an approved works by the open hearth process, acid or basic, an electric furnace process or other approved process.

**603** The forgings are to be made from ingots cast in chill moulds with the larger cross-section uppermost and with efficient feeder heads. They are to be gradually and uniformly hot worked from sound ingots. Adequate top and bottom discards are to be made to ensure freedom from piping and harmful segregation in the finished forgings.

Forgings are to be brought as nearly as possible to the finished shape and size by hot working. Where practicable they are to be worked so as to cause metal flow in the most favourable direction having regard to the mode of stressing in service. In the case of combined crank web and pin forgings, the forging procedure is to be submitted for approval.

Unless otherwise approved the maximum sectional area of any part of a forging (as forged) is not to exceed:—

1/3A where the length of any section is greater than its diameter.

2/3A where the length of any section is less than its diameter (e.g. a collar).

A is average sectional area of the ingot or of the ingot after upsetting if such an operation is involved.

Disc or ring type forgings are to be made from cylindrical pieces which have been hot cut or machined from a bloom or billet. The thickness of any part of a disc (as forged or as stamped) is to be not more than one half of the length of the piece from which it was formed.

### Composition of the Steel

**604** The forgemaster is to provide details of the cast analysis of the steel used for each forging and the general details of the heat treatment.

The composition of the carbon steel is restricted as follows:—

| | | |
|---|---|---|
| Carbon | ... | 0,50% max. |
| Silicon | ... | 0,10% to 0,45% |
| Manganese | ... | 0,30% to 1,00% |
| Sulphur | ... | 0,050% max. |
| Phosphorus | ... | 0,050% max. |

Where it is proposed to use a carbon steel forging in welded construction for ship or machinery, the carbon content of the steel is generally not to exceed 0,23 per cent. In the order for the forging it is to be stated that the steel is to be of weldable quality and the maximum carbon content is also to be quoted. Alternatively, a particular grade of steel that has been approved for the purpose may be specified in the order.

### Heat Treatment

**605** Forgings are to be heat treated in properly constructed furnaces which are efficiently maintained and have adequate temperature control. If a forging is subsequently heated for any further forging work, it is again to be properly heat treated.

The forgings are to be heated to a uniform temperature above the upper critical point to refine the grain and are to be:—

(a) fully annealed by cooling slowly in the furnace in a uniform manner,

*or* (b) normalised by cooling in air followed by a tempering treatment to relieve internal stresses if the diameter of the body of the forging is equal to or greater than the values given in Table 1. Smaller diameter forgings may also be tempered after the normalising heat treatment at the option of the forgemaster,

*or* (c) hardened by quenching in oil or by other recognised method followed by tempering. However, hardening by any method is only to be adopted with the consent of the Surveyor. Unless otherwise agreed, forgings are to be rough machined prior to the hardening heat treatment.

**TABLE 1**

DIMENSIONS OF FORGINGS TO BE TEMPERED AFTER NORMALISING

| % CARBON CONTENT OF STEEL | | EQUIVALENT DIAMETER |
|---|---|---|
| | *Up to and* | OF BODY OF FORGING |
| *Over* | *including* | |
| 0,40 | 0,50 | 380 mm |
| 0,35 | 0,40 | 510 ,, |
| 0,30 | 0,35 | 710 ,, |
| 0,25 | 0,30 | 890 ,, |
| | 0,25 | 1015 ,, |

### Flame Cutting of Forgings

**606** The shaping of forgings or thick slabs by flame cutting is to be undertaken in accordance with a procedure approved by the Surveyor. Where possible, flame cutting is to be carried out before the heat treatment operation of 605. Pre-heating is to be employed when necessitated by the thickness and/or composition of the steel.

For machinery parts that are subjected to cyclic stress during service, a depth of at least 12,5 mm. is to be removed by machining from flame cut surfaces. If required by the Surveyor, selected areas of such machined surfaces are to be prepared and then examined by magnetic crack detection or other equivalent method to his satisfaction.

### Provision of Test Pieces

**607** Sufficient material of not less than the sectional dimensions of the body is to be formed integral with forgings and is to be used for test purposes. This material is not to be removed from a forging until the heat treatment is completed except where an alternative procedure has been specially approved, and the Surveyor has identified by stamp marks the test portions and the forgings.

**608** The tensile strength and ductility of the material of each forging is to be determined from standard test pieces which are to be machined from portions cut longitudinally or in the direction of principal grainflow. Where material for testing cannot reasonably be provided from the longitudinal direction, the test pieces may be cut in a transverse direction. Test pieces are to be taken transversely from slabs for crank webs.

Test portions are not to be forged down and neither these nor the test pieces machined therefrom are to be treated in any way which may influence the properties of the material.

### Number of Tests

**609** At least one tensile and one cold bend test piece are to be taken from each forging or multiple forging. In the case of forgings or multiple forgings exceeding both 3000 kg. in weight and 2,44 metres in length, one tensile test and one cold bend test piece are to be taken from each end of each forging or multiple forging.

### Dimensions of Test Pieces

**610** Tensile test pieces are to be machined to a form which complies with an appropriate National Standard, providing the diameter within the gauge length is not less than 12,5 mm. The gauge length may be either 4 or 5,65 times the square root of the cross sectional area of the test section. Test pieces of non-standard dimensions or of smaller size may only be used with the consent of the Surveyor and in special cases where the dimension of the forging will not permit the use of the required test pieces. In such cases the test piece is to be of the largest practicable size associated with a standard gauge length.

**611** The bend test pieces are to be machined to a rectangular section of either 25 mm. wide by 19 mm. thick where the specified minimum tensile strength of the steel does not exceed 57 kg. per mm.$^2$ or 19 mm. wide by 9,5 mm. thick where the specified minimum tensile strength of the steel is in excess of 57 kg. per mm.$^2$. The edges of the test pieces may be rounded to a radius of not more than 1,5 mm. in each case.

### Test Requirements

**612** Tensile tests, which are to be made in the presence of the Surveyor or an authorised deputy, are to be carried out by competent personnel and in an approved machine of adequate capacity. The machine is to be maintained in an efficient and accurate condition, and is to be checked and calibrated at suitable intervals agreed by the Society.

**613** For crank webs (*see* H 208 and H 608) and other parts where minimum yield stresses are specified, these stresses are to be determined, using a moderate rate of loading, by the drop-of-the-beam of a lever type testing machine or the hesitation of the gauge needle of a hydraulic testing machine. Where such methods are unacceptable to the Surveyor an extensometer or dividers may be used. In the latter case the yield stress is to be taken as the stress corresponding to an increase of 1/200 of the original gauge length.

**614** Forgings are to have tensile strengths between 44 and 71 kg. per mm.$^2$; the specified range of tensile strength for any forging is not to exceed 7,9 kg. per mm.$^2$. Where tensile test pieces are taken from each end of a forging or multiple forging the test results are not to vary by more than 6,3 kg. per mm.$^2$ in addition to complying with the previous requirements.

Screwshaft forgings are, in general, to be restricted to a range of tensile strength of 44 to 52 kg. per mm.$^2$.

Sternposts, propeller posts, rudders and other important ship forgings, and propeller nuts may be made of a specially soft ingot steel, the tensile strength being within the limits of 35 to 41 kg. per mm.$^2$.

The percentage elongation of tensile test pieces measured after fracture is not to be less than the minimum given in Table 2, appropriate to the tensile strength of the steel.

Where it is proposed to use steel of higher carbon content than that permitted in 604 and/or a higher tensile strength than specified above, the details are to be submitted for approval.

**615** Bend test pieces are to withstand, without fracture, being cold bent through an angle of 180° to an internal radius (or round a former having a radius) not greater than that specified in Table 3 according to the tensile strength. The test pieces are to be bent over the thinner section.

The bending may be done by pressure or blows.

## TABLE 2

## TENSILE PROPERTIES OF CARBON STEEL FORGINGS

### Minimum Elongation Per Cent

| Actual Tensile Strength kg. per mm.² | $L = 4\sqrt{A}$ | | $L = 5{\cdot}65\sqrt{A}$ | |
|---|---|---|---|---|
| | Longitudinal or in the Direction of Principal Grain Flow | Transverse or Across the Direction of Principal Grain Flow | Longitudinal or in the Direction of Principal Grain Flow | Transverse or Across the Direction of Principal Grain Flow |
| 35 to 41 | 31 | 25 | 27 | 21 |
| over 41 ,, 44 | 29 | 24 | 25 | 20 |
| ,, 44 ,, 47 | 28 | 23 | 24 | 19 |
| ,, 47 ,, 50 | 27 | 21 | 23 | 18 |
| ,, 50 ,, 54 | 26 | 20 | 22 | 17 |
| ,, 54 ,, 57 | 25 | 19 | 21 | 16 |
| ,, 57 ,, 60 | 23 | 18 | 19 | 15 |
| ,, 60 ,, 63 | 22 | 17 | 18 | 14 |
| ,, 63 ,, 66 | 21 | 16 | 17 | 13 |
| ,, 66 ,, 71 | 19 | 14 | 15 | 11 |

## TABLE 3

## BEND TESTS FOR CARBON STEEL FORGINGS

| Actual Tensile Strength kg. per mm.² | Maximum Internal Radius of bend or Radius of Former | |
|---|---|---|
| | Longitudinal or in the Direction of Principal Grain Flow | Transverse or Across the Direction of Principal Grain Flow |
| Up to 50 | $\frac{1}{3}$T | $\frac{2}{3}$T |
| over 50 to 57 | $\frac{1}{2}$T | T |
| ,, 57 ,, 63 | $\frac{2}{3}$T | $1\frac{1}{3}$T |
| ,, 63 ,, 71 | T | 2T |
| | Where T=thickness of test piece | |

### Additional Tests before Rejection

**616** Where either the tensile test or the bend test, or both, fail, and the Surveyor considers the fractured test piece or test pieces, or the results obtained therefrom, do not fairly represent the quality of the forging, two further test pieces are to be taken for each piece that failed. In such cases the quality of the forging is to be judged by the result of the retests and not by the original test or tests which failed.

**617** If the results of mechanical tests and retests on a forging fail to meet the requirements of 613 to 616 inclusive, the maker may reheat-treat the forging providing the Surveyor's consent is obtained. Forgings so heat treated are to be presented for further complete mechanical tests. Should the tests and retests again fail to meet the requirements, a further heat treatment is permitted with the consent of the Surveyors. No forging is to be completely reheat-treated more than twice. If any test, made after the permissible number of heat treatments, fails to meet the requirements the forging is not to be accepted by the Surveyor.

### Inspection of Forgings

**618** The Surveyor is to examine each forging before despatch by the forgemaster. Forgings are to be sound and free from cracks, harmful flaws and segregation.

In the case of forgings for crankshafts which have finished pin or journal in excess of 510 mm. diameter, the forgemaster is to carry out an ultrasonic test on each forging, using competent personnel and reliable and efficiently maintained equipment.

In the event of any forging proving unsound during subsequent machining, erection or trials, such forging is to be rejected notwithstanding any previous certificate of satisfactory test and inspection.

### Branding

**619** Every forging, after it has withstood satisfactorily the prescribed tests and inspection, is to be clearly and distinctly marked by the Surveyor indicating that the forging has complied with the requirements of the Society.

### Small Carbon Steel Forgings

#### General

**620** This section covers small carbon steel forgings made from billet or bar and intended for important stressed applications, e.g. fuel pump bodies, flanges, small diameter shafts, deck fittings, etc.

**621** The steels of billets or bars used for the manufacture of the forgings are to comply generally with the requirements of 602, 603 and 604. Where the billets or bars are supplied to a forge that is not an integral part of an approved steelworks, the Surveyor at the forge is to be provided with a certificate that states the name of the manufacturer of the billets or bars; the process of manufacture of steel; the cast number and the ladle analysis.

#### Heat Treatment

**622** Forgings are to be heat treated in accordance with 605.

#### Provision of Test Pieces

**623** Unless otherwise agreed by the Surveyor, material for test purposes is to be provided in accordance with 607. Where a number of individual forgings of the same type are produced, a system of batch testing may be adopted by the Surveyor. In such cases forgings are to be presented for test and inspection in groups of the same cast and the same heat treatment batch.

#### Test Requirements

**624** Where a system of batch testing is adopted, the hardness of each forging is to be determined including those from which material is to be cut for the provision of tensile and bend test pieces. The hardnesses of the forgings are to comply with a specification approved by the Surveyor before manufacture of the parts.

Tensile and bend test pieces are to be prepared and tested in accordance with 610, 611 and 612. The results of the tests and conditions of retest are to comply with 613 to 617 inclusive.

#### Quantity Production

**625** Where small and identical forgings are produced in large quantities, the Surveyor may adopt a suitable system of quality control provided it is approved and the required standard of inspection is maintained by the firm.

#### Inspection of the Forgings and Branding

**626** The Surveyor is to examine forgings before despatch. The forgings are to be sound and free from cracks and harmful flaws and segregation. In the event of any forging proving unsound during machining or erection, such forging is to be rejected notwithstanding any previous certificate of satisfactory test and inspection.

Forgings which have withstood satisfactorily the prescribed tests and inspections are to be marked in accordance with 619.

#### Alternative Specifications

**627** Where it is proposed to use a steel of higher carbon content than that permitted in 604 and/or of higher tensile strength than that specified in 614, the details are to be submitted for approval.

### Ferritic Steel Forgings for Turbines, Compressors and Turbine Driven Generators

#### General

**628** Ferritic steel used for the manufacture of forgings for turbine rotors, discs and spindles, turbine driven generators rotors and compressor rotors is to be made at an approved works by the open hearth, electric furnace or other approved process.

**629** Ingots are to be cast in chill moulds with the larger section uppermost, and with efficient refractory feeder heads.

**630** The forgings may be made of carbon steel or alloy steel. The composition of the steel is to be restricted as follows:—

| | | |
|---|---|---|
| Carbon | ... ... | 0,45% maximum |
| Silicon | ... ... | 0,15% to 0,45% |
| Sulphur | ... ... | 0,050% maximum |
| Phosphorus | ... | 0,050% maximum |

Where mechanical tests are required from forgings in either the radial or the tangential direction or both, the sulphur and the phosphorus contents of the steel are not to exceed 0,040 per cent each.

Specifications of alloy steel forgings giving the proposed chemical composition, heat treatment and mechanical properties are to be submitted for approval with the plans of the components.

When it is proposed to use rotors of welded construction the compositions of the steel for the forgings are to be submitted for special consideration. These are to comply with the above limits of composition except that generally the carbon content is not to exceed 0,25 per cent.

**631** The steelmaker is to provide details of the cast analysis of the steel used for each forging and the general details of heat treatment.

**632** All forgings are to be sound and free from harmful defect. Forgings may be rejected if harmful defects are revealed during machining, notwithstanding acceptance during earlier stages of manufacture.

**633** Orders and drawings for rotor forgings are to state whether the rotor is intended for propulsion or auxiliary machinery, and the shaft horse power of auxiliary

turbines. In the case of a rotor which is to be tested for thermal stability the maximum operating temperature and the proposed test temperature are also to be stated.

### Manufacturing of Forgings

**634** Thermal treatments of the steel are to be such as to avoid the formation of hair line cracks.

**635** The forgings are to be gradually and uniformly forged from sound ingots from which at least 5 per cent of the total weight of the ingot is removed from the bottom and not less than the following percentages of the total weight from the top of the ingot:—

| *Weight of ingot* | *Minimum top discard* |
|---|---|
| Below 2000 kg. ... | 15 per cent |
| 2000 to 5000 kg. ... | 18 ,, ,, |
| 5000 to 10000 kg. ... | 22 ,, ,, |
| Over 10000 kg. ... | 25 ,, ,, |

**636** For rotor forgings the sectional area of any part (as forged) is not to exceed one half of the average sectional area of the ingot. Where an upsetting operation is included in the manufacturing procedure the above requirement is to apply to the sectional area of the upset bloom and not to the ingot.

**637** For spindle forgings the sectional area of any part (as forged) is not to exceed one third of the average sectional area of the ingot except at collars where the area is not to exceed two thirds of the sectional area of the ingot.

**638** Turbine discs are to be forged or stamped from cylindrical pieces which have been hot cut or machined from a bloom or a billet. The thickness of any part of a disc (as forged or as stamped) is to be not more than one half of the length of the piece from which it was formed.

### Heat Treatment

**639** Forgings are to be carefully heat treated in properly constructed furnaces. At a suitable stage of manufacture they are to be re-heated above the upper critical point to refine the grain, cooled in an approved manner and then tempered to produce the desired mechanical properties.

Where forgings receive their main heat treatment prior to machining they are to be stress relieved at an intermediate machining stage.

The tempering and stress relieving temperatures are to be not less than 550° C. (1020° F.) in the case of carbon steels and 600° C. (1110° F.) in the case of alloy steels. The holding times and subsequent cooling rates are to be such that the forging in its final condition is free from harmful residual stresses.

The stress relieving temperature is not to exceed the temperature at which the forging was previously tempered.

### Number of Tests

**640** Sufficient material is to be left on forgings to provide specimens for mechanical tests. Excess test material is not to be completely severed from a forging until all the required mechanical tests have been completed with satisfactory results.

Test pieces are to be machined from pieces which are not to be cut from the forging until all heat treatment has been completed. In this connection a thermal stability test does not form part of the heat treatment of a turbine rotor forging.

**641** At least one longitudinal tensile and one cold bend test piece are to be taken to represent the material of each forging (or multiple forging) excluding discs. In the case of forgings (or multiple forgings) exceeding both 3000 kg. in weight and 1,83 metres in length not less than one tensile and one cold bend test are to be taken from each end of each forging (or multiple forging).

**642** For rotor forgings of all main propulsion machinery and of auxiliary turbines exceeding 1500 s.h.p. tangential and, where dimensions permit, radial tensile and bend tests are also to be taken from the end of the body corresponding to the top end of the ingot.

**643** For each turbine disc, at least one tensile and one bend test piece are to be cut in a tangential direction from material at the hub.

### Mechanical Properties

**644** Tensile test pieces of the round proportional type are to be used with a gauge length of $4\sqrt{A}$. For longitudinal and tangential tests the cross sectional area is to be not less than 1,6 cm.$^2$ and for radial tests not less than 0,65 cm.$^2$

For carbon steel forgings the tensile strength is to be specified as a range of 7,9 kg. per mm.$^2$ within the limits of 44 to 71 kg. per mm.$^2$ For alloy steel rotor forgings the specified range is to be 12,6 kg. per mm$^2$ within the limits of 44 to 91 kg. per mm.$^2$ For discs and other alloy steel forgings the specified range is also to be 12,6 kg. per mm.$^2$ within the limits of 44 to 107 kg. per mm.$^2$

In all cases the tensile strength of the steel is to be within the specified and approved range.

Where more than one tensile test piece is taken from a single forging, the tensile strengths are to be within the specified range but for alloy steels these are not to differ by more than 9,5 kg. per mm.$^2$

**645** Unless otherwise specified and approved, the yield stress or 0,5 per cent proof stress, as appropriate for the type of steel, is not to be less than 50 per cent of the actual tensile strength for normalised material and not less

than 60 per cent of the actual tensile strength for low alloy material in the quenched and tempered condition.

**646** The reductions of area at fracture as determined on tensile test pieces are not to be less than:—

35% for longitudinal test
30% for tangential tests
20% for radial tests.

**647** The percentage elongations at fracture of tensile test pieces are to comply with the requirements given in Table 4.

**648** If the percentage of elongation of any tensile test specimen is less than that prescribed in Table 4, and any part of the fracture is outside the middle half of the gauge length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

**649** Bend test pieces are to be machined to a section of 19 mm. by 9,5 mm. The test pieces are to be bent cold without fracture to angles of not less than 180° for a longitudinal test piece; 150° for a tangential test piece; and 120° for a radial test piece.

The maximum radius of the formers is given in Table 4.

**650** Where either the tensile test or bend test or both fail, and the Surveyor considers that the results may not fairly represent the quality of the forging, two additional test pieces may be taken from a similar part of the forging if requested by the maker. In such cases the quality of the forging is to be judged on the results of the two retests and not on the results of the original tests that failed.

**651** If the results of mechanical tests and retests on a forging fail to meet the requirements of 644 to 650 inclusive, the maker may reheat-treat the forging providing the Surveyor's consent is obtained. Forgings so treated are to be presented for further complete mechanical tests.

**652** Alternative requirements of National Standard and other specifications, which provide reasonable equivalents in mechanical properties, may be accepted if approved. Impact tests in place of bend tests may also be accepted if approved.

### Additional Inspections

**653** Rotor forgings for propulsion machinery and for auxiliary turbines exceeding 1500 s.h.p. are to be hollow bored for internal examination. The surfaces of the bores are to have a fine, smooth finish. The Surveyor is to be provided with an optical instrument of suitable magnification to examine the bores.

At the discretion of the Surveyor, alternative methods of proving the internal soundness of such forgings may be accepted.

**654** The end faces of rotor forgings are to be machined to a fine smooth finish at the forge for the purposes of examination.

**655** The end faces of the boss and the bore surface of each turbine disc are to be machined to a smooth finish and examined by a suitable method of magnetic crack detection.

### Stability Testing of Turbine Rotors

**656** Thermal stability tests after heat treatment and rough machining of the turbine rotors referred to in H 410 are to be undertaken in properly constructed furnaces, using accurate and reliable measuring equipment. Each test is to be carried out in accordance with the following recommended procedure:—

(*a*) Five bands are to be machined concentric with the axis of rotation. Two of these are to be reference bands and are to be positioned at or near the locations of the bearings. The remaining three bands are to be test bands located one as near as possible to the mid-length, and the other two near each end of the body. Where the length of a rotor is such that five bands cannot be provided, alternative proposals are to be submitted to the Surveyor for his approval.

(*b*) Four positions, 90° apart, are to be stamped A, B, C and D on the coupling end of the rotor.

(*c*) The whole of the body and as much of the shaft at either end as will include the positions of the glands are to be enclosed in the furnace. In the case of a rotor having an overhung astern wheel, the astern wheel is also to be enclosed in the furnace during the first test. (*See* H 410.)

(*d*) The rotor is to be rotated at a uniform and very slow speed.

(*e*) The deflections at all bands are to be recorded at the A, B, C and D positions. Initial cold readings are to be taken prior to heating.

(*f*) The rotor is to be heated uniformly and slowly. Temperatures are to be recorded continuously at the surface of the rotor and if practicable in the bore at the mid-length of the body. Under no circumstances is the surface temperature to exceed the temperature at which the rotor was tempered. During heating the rate of rise of temperature is to be such as to avoid excessive temperature gradients in the rotor.

(*g*) The maximum or holding temperature is to be not less than 28° C. (50° F.) above the maximum operating temperature of the rotor. For the purposes of the test the holding period is to start when

the rotor has attained a uniform and specified temperature. The rotor is to be held under the specified temperature conditions until not less than three consecutive hourly readings of deflections show the radial eccentricity to be constant within 0,006 mm. on all test bands.

(*h*) The turbine rotor is to be rotated during cooling until the temperature is not more than 100° C. (212° F.). The rate of cooling is to be such as to avoid excessive temperature gradients in the rotor.

(*i*) Final cold readings are to be taken.

**657** The movements of the axis of the rotor in relation to the reference bands are to be determined from polar plots of the deflection readings.

The radial movement of the shaft axis as determined by the difference between the final hot and the final cold movements is not to exceed 0,025 mm. on any one band.

As verification that test equipment and conditions are satisfactory it is required that similar determinations of differences between initial cold and final cold movements do not exceed 0,025 mm. on any one band.

If the results of the test on a rotor fail to meet either or both of the above requirements, the test may be repeated if requested by the maker and agreed by the Surveyor.

**658** In the case of a rotor failing to meet the requirements of a thermal stability test, the rotor is deemed unacceptable. Proposals for the rectification of thermal instability of a rough machined rotor are to be submitted for special consideration.

### Branding

**659** Every forging to be marked in accordance with 619.

### Hot Rolled Steel Bars, from which Shafts and other parts are machined

**660** Hot rolled steel bar intended for propeller and straight shafting, rudder stocks, shafts for electric motors, generators and other suitable applications is not to exceed 250 mm. in diameter and is to comply generally with the requirements given in 602 to 619. One tensile and one bend test are to be taken from each bar, as supplied. If the weight of an individual bar is in excess of 1000 kg., tensile and bend tests are to be taken from each end.

TABLE 4

| Minimum Specified Tensile Strength | Minimum Percentage Elongation for gauge length of $4\sqrt{A}$* | | | Maximum radius of former in millimetres for bend test | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 180° | | 150° | | 120° | |
| Kg. per mm.² | L. | T. | R. | L. | T. | R. | | | |
| 44 | 28 | 23 | 20 | 9,5 | 9,5 | 9,5 | | | |
| 47 | 28 | 23 | 20 | 9,5 | 9,5 | 9,5 | | | |
| 55 | 25 | 20 | 18 | 12,5 | 12,5 | 12,5 | | | |
| 63 | 22 | 18 | 16 | 19 | 19 | 19 | | | |
| 71 | 20 | 16 | 14 | 19 | 19 | 19 | | | |
| 79 | 18 | 14 | 12 | 19 | 19 | — | | | |
| 87 | 17 | 13 | — | 25 | 25 | — | | | |
| 94 | 17 | 12 | — | 25 | 25 | — | | | |

L.—For longitudinal tests.
T.—For tangential tests.
R.—For radial tests.
Intermediate values are to be obtained by interpolation.

* A is the cross sectional area of the tensile test piece.

**Yield stress or 0,5% proof stress** (*See* 645)

Not less than 50% of the actual tensile strength for normalised material.

Not less than 60% of the actual tensile strength for low alloy material in the quenched and tempered condition.

**Reduction of Area** (*See* 646)

Not less than 35% for longitudinal tests.
„ „ „ 30% for tangential tests.
„ „ „ 20% for radial tests.

## Section 7

### SEAMLESS STEEL DRUMS FOR BOILERS

**Process**

**701** The steel is to be made by the open hearth process, acid or basic.

**Discard**

**702** Sufficient discard shall be made from the top and bottom of each ingot to ensure soundness in the portion used for forging, and sulphur prints may be taken to demonstrate that this condition has been fulfilled.

**Forging**

**703** The forging shall be made from a solid cast ingot, punched, bored or trepanned, or alternatively hollow cast ingots may be used. The resultant wall in the case of the solid cast ingot, or the wall of the hollow ingot, as cast, shall be reduced in thickness by at least two-thirds in the process of forging.

The Committee will be prepared to give consideration to the circumstances of any special case.

**Heat Treatment and Testing**

**704** Sufficient material shall be left on each end of each forging to enable tangential tests to be taken. These tests are to consist of one tensile test and one bend test from each end. In the case of open-ended drums the test material shall not be parted off before heat treatment, but, if the drums are closed in, the test rings may be parted prior to this operation; subsequently the test rings and the forging shall be simultaneously heat treated in the same furnace.

If desired, test pieces may be heated for the purpose of straightening, but this operation must not cause any alteration in the sectional area of the test pieces, which are subsequently to be heat treated simultaneously with the drum.

**Tensile Tests**

**705** The tensile breaking strength is to be between the limits of 44 and 63 kg. per mm.$^2$, but the difference in the tensile strengths at each end of a forging is not to exceed 6,3 kg. per mm.$^2$

The percentage of elongation measured on a standard test piece (*see* P 608) is to be between 29 and 17, and in no case is the sum of 0,635 times the tensile breaking strength and corresponding elongation to be less than 57.

**Bend Tests**

**706** Test pieces 25 mm. by 19 mm. are to be capable of being bent cold through an angle of 180 degrees, the internal radius of the bend being not greater than that specified below:—

| | |
|---|---|
| Up to 50 kg. per mm.$^2$ ... ... ... ... | 6 mm. |
| Above 50 kg. and up to 56,5 kg. per mm.$^2$ ... | 9,5 mm. |
| Above 56,5 kg. and up to 63 kg. per mm.$^2$ ... | 16 mm. |

**Retesting**

**707** Should either the tensile test or the bend test fail, two further specimens may be tested and if the results obtained from both are satisfactory the forging shall be accepted. In the event of either or both retests failing, the forging may be again heat treated and re-presented for test.

## Section 8

### REDUCTION GEAR PINIONS AND GEAR WHEELS

**General**

**801** Steels used for pinions, pinion sleeves and wheel rims are to comply with the following requirements. Steels for other parts used in the construction of gearing are to comply with the requirements of P 3, P 5 or P 6 as may be applicable.

The steel is to be made by the acid open hearth, electric furnace or other approved process and is to contain not more than 0,04 per cent of sulphur or phosphorus.

Ingots are to be cast in chill moulds with the larger diameter or cross section uppermost, and with efficient refractory feeder heads.

A certificate giving the actual chemical analysis of the steel is to be provided in all cases.

**802** Specifications for materials of pinions, pinion sleeves, wheel rims, flexible couplings and quill shafts giving chemical analysis, heat treatment and mechanical properties are to be submitted for approval with the plans of gearing, as required by H 503.

**803** All forgings are to be sound and free from defects. Forgings may be rejected after the cutting of teeth if defects are then revealed, notwithstanding acceptance during earlier stages of manufacture.

#### Pinions

**Materials**

**804** Pinions are to be made from approved alloy steels which in the heat treated condition have tensile strengths between 63 and 120 kg. per mm.$^2$ The specified range of tensile strength is not to exceed 9,4 kg. per mm.$^2$ for any forging (*see also* H 502).

Any of the following type steels will be accepted for this service within the range of tensile strengths for which they are suitable:—

3% Ni
3½% Ni
1¾% Ni+Cr+Mo
2½% Ni+Cr+Mo
3% Ni+Cr+Mo
4¼% Ni+Cr+Mo
3% Cr+Mo

NOTE.—The percentage figures are applicable to the first element only: for instance 1¾% Ni+Cr+Mo is to be interpreted as a steel having a nominal Ni content of 1¾% with, in addition, appropriate contents of Cr and Mo.

Where it is desired to use other alloy steels or case-hardening steels full details are to be submitted for consideration.

### Manufacture of Forgings

**805** The forgings are to be gradually and uniformly forged from ingots from which at least 5 per cent of the total weight of the ingot is removed from the bottom and not less than the following percentage of the total weight from the top of the ingot:—

| *Weight of Ingot* | *Minimum top discard* |
|---|---|
| Below 2000 kg. ... ... | 15 per cent |
| 2000 to 5000 kg. ... ... | 18 ,, ,, |
| Over 5000 kg. ... ... | 25 ,, ,, |

**806** The sectional area of any part of the forging (as forged) is not to exceed:—

One half of the sectional area of the ingot where the length at any diameter is greater than its diameter or for any part in which teeth are to be cut.

Two thirds of the sectional area of the ingot where the length at any diameter is less than its diameter, e.g., a collar.

Sleeves are to be hollow forged or hollow rolled where practicable.

**807** The forgings are to be made with sufficient material on the portion on which the teeth will be cut to allow not less than the following amounts being machined from surfaces of the finished forging before heat treatment, but leaving 6,5 mm. on all surfaces:—

Large forgings for pinions 150 mm. and over in diameter over the toothed portion when finished—25 mm. on diameters.

Small forgings for pinions under 150 mm. in diameter over the toothed portion when finished—19 mm. on diameters.

### Heat Treatment

**808** The forgings are to be normalised and tempered or oil-hardened and tempered in accordance with the approved specification.

### Number of Tests

**809** Tensile and impact tests are to be provided as follows:—

For each pinion forging (or multiple forging) not exceeding 200 mm. in body diameter and 1,22 metres in overall length, a set of longitudinal test pieces is to be taken from one end; where the overall length exceeds 1,22 metres a set is to be taken from both ends.

In addition to the foregoing, a set of transverse test pieces is to be taken from one end of the body portion where the body diameter exceeds 200 mm. and the total length of body portion does not exceed 760 mm.; where this length exceeds 760 mm. a set is to be taken from both ends. In cases where the difference in diameters between the body and journal does not permit the selection of transverse tests, these tests may be taken from the ends of the forgings.

For each pinion sleeve forging (or multiple forging) not exceeding 760 mm. in length, a set of circumferential test pieces is to be taken from one end; where the length exceeds 760 mm. a set is to be taken from both ends.

### Batch Testing

**810** Where a number of pinion forgings of the same dimensions are forged separately from the same cast and heat treated together in batches, and each forging does not exceed either a length of 1,22 metres or a weight of 150 kg. as forged, the following test procedure may be adopted.

Sufficient material for test purposes shall be left on 5 per cent of the forgings constituting a heat treatment batch, the minimum number being two forgings per batch. Sets of longitudinal and transverse tests from each of these forgings in accordance with the foregoing and including sulphur prints may be taken as representative of the batch. The results of these tests are to be confirmed by Brinell tests carried out on all forgings in accordance with 812.

### Mechanical Properties

**811** The mechanical properties of the forgings, after heat treatment, are to comply with the requirements of Table 1.

Test pieces taken from the circumference of pinion sleeves are to be regarded, for Table 1 requirements, as longitudinal tests where sleeves are hollow-forged and as transverse tests where sleeves are solid-forged and machined hollow (*see* 806).

TABLE 1—MECHANICAL PROPERTIES FOR PINIONS

MATERIAL—ALLOY STEEL

| SPECIFIED MINIMUM TENSILE STRENGTH | MINIMUM YIELD STRESS | MINIMUM PERCENTAGE ELONGATION ON 50 mm. | | MINIMUM IMPACT VALUES | | | | | | | | | | HEAT TREATMENT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | LONGITUDINAL | | | | | TRANSVERSE | | | | | |
| | | | | kg. metres | kgm/cm.² | | | | kg. metres | kgm/cm.² | | | | |
| kg. per mm.² | kg. per mm.² | Longitudinal | Transverse | Izod | Charpy Key-Hole | D.V.M. | V.S.M. | Mesnager | Izod | Charpy Key-Hole | D.V.M. | V.S.M. | Mesnager | |
| 63 | 44 | 23 | 16 | 2,8 | 4,1 | 4,6 | 4,7 | 5,2 | 2,1 | 3,2 | 3,6 | 3,6 | 4,0 | Normalised and tempered |
| 63 | 44 | 23 | 16 | 4,8 | 6,7 | 7,8 | 7,8 | 8,7 | 2,8 | 4,1 | 4,6 | 4,7 | 5,2 | Oil-hardened and tempered |
| 71 | 52 | 22 | 15 | 4,7 | 6,5 | 7,6 | 7,7 | 8,5 | 2,5 | 3,7 | 4,2 | 4,2 | 4,7 | |
| 79 | 60 | 20 | 14 | 4,4 | 6,2 | 7,2 | 7,3 | 8,0 | 2,3 | 3,6 | 4,0 | 4,0 | 4,5 | |
| 87 | 69 | 18 | 13 | 4,1 | 5,8 | 6,7 | 6,8 | 7,5 | 2,1 | 3,2 | 3,6 | 3,6 | 4,0 | |
| 94 | 76 | 17 | 12 | 3,9 | 5,5 | 6,3 | 6,4 | 7,1 | * | * | * | * | * | |
| 102 | 82 | 14 | 10 | 3,6 | 5,1 | 5,9 | 6,0 | 6,6 | * | * | * | * | * | |
| 110 | 91 | 13 | 9 | 3,0 | 4,4 | 5,1 | 5,1 | 5,7 | * | * | * | * | * | |

*Transverse impact tests are to be made and results recorded.

Tensile tests are to be made on a standard test piece of 50 mm. gauge length and 14 mm. diameter.

Impact tests are to be made on Izod test specimens 10 mm. square with a V notch 2 mm. deep having an included angle of 45 degrees with 0,25 mm. radius at root or a round test specimen 11,5 mm. diameter with a V notch may be used. Alternatively, other 10 mm. square test specimens of the types indicated in Tables 1 and 2 may be adopted.

### Hardness Tests

**812** Hardness tests are to be taken on all forgings after machining to 6,5 mm. over the finished diameter after heat treatment. The impressions are to be taken at each end of two diameters at right angles in three different positions over each toothed portion of the pinion. The forging will be considered sufficiently uniform if the difference between the highest and lowest value does not exceed 30 in Brinell Numbers, or their equivalent.

### Sulphur Prints

**813** Sulphur prints are to be taken over the whole of the body portions of the forging in which teeth are to be cut, and in addition, from each end of the body portions to verify that the steel is clean and free from harmful segregations.

When considered necessary by the Surveyors, these prints are to be supplemented by magnetic crack detection examinations or other approved tests.

## GEAR WHEELS

**814** Wheel rims and solid-forged wheels are to be made from approved steels which in the heat treated conditions have tensile strengths between 47 and 104 kg. per mm.² The specified range of tensile strength is not to exceed 7,9 kg. per mm.² for the carbon steel and 9,4 kg. per mm.² for the alloy steel forgings.

Any of the following type steels will be accepted for this service up to a tensile strength of 71 kg. per mm.$^2$ within the range for which they are suitable.

Carbon Steels (0,25% C to 0,55% C)
1% Ni
1% Cr+Mo

Where it is proposed to use other alloy steels of greater tensile strength, or case-hardening steels, full details are to be submitted for consideration.

### Manufacture of Forgings

**815** Wheels and rims are to be gradually and uniformly forged or rolled from ingots from which the following top and bottom discards have been taken. If rims are made from trepanned ingots sufficient discard shall be made from the top and bottom to ensure soundness in the portion used for forging, and sulphur prints may be taken to demonstrate that this condition has been fulfilled. If the rims or wheels are made from solid ingots the top and bottom discards are to be not less than required in the case of pinions (*see* 805). Rolled bar is not to be used.

### Heat Treatment

**816** Wheel and rim forgings are to be normalised and tempered or oil-hardened and tempered in accordance with the approved specification.

### Number of Tests

**817** Tensile and bend tests are to be provided for carbon steels and tensile and impact tests for alloy steels as follows:—

For single wheel or rim forgings greater than 2,44 metres in diameter or 3000 kg. in weight and for multiple forgings, one set of circumferential tests is to be taken from each end of the forging from positions diametrically opposed, provided that in the case of multiple forgings all the portions cut from it are heat treated together. For smaller single wheels or rims a set of circumferential test pieces is to be taken from one end of the forging.

### Batch Testing

**818** Where a number of wheels or rims of the same dimensions are forged from the same cast and heat treated together in batches, and do not exceed 150 kg. each as forged, the following test procedure may be adopted.

Sufficient material for test purposes shall be left on 5 per cent of the forgings constituting a heat treatment batch, the minimum number being two forgings per batch. Sets of transverse tests from each of these forgings in accordance with the foregoing may be taken as representative of the batch.

### Mechanical Properties

**819** The mechanical properties of the forgings, after heat treatment, are to comply with the requirements of Table 2.

The tensile and impact test pieces are to be of the type and size described in 811.

The bend test pieces are to be machined to a rectangular section of 25 mm. wide by 19 mm. thick for carbon steels not exceeding 63 kg. per mm.$^2$ tensile strength and 19 mm. wide by 9,5 mm. thick where the tensile strength exceeds 63 kg. per mm.$^2$ The edges are to be rounded to a radius of 1,5 mm. in each case. These test pieces are to withstand without fracture, being bent cold through an angle of 180 degrees over a former having a radius not greater than that specified in Table 2. They are to be bent over the thinner section. The bending may be performed either by pressure or by blows.

### Hardness Tests

**820** Hardness tests are to be made on all wheels and rims as in 812 except that for carbon steels the difference between the highest and lowest value is not to exceed 20 in Brinell Numbers, or their equivalent, for steels of tensile strength not exceeding 63 kg. per mm.$^2$ and 30 in Brinell Numbers for steels over 63 kg. per mm.$^2$

### Sulphur Prints

**821** Sulphur prints are to be taken from the ends of the wheel rim to verify that the steel is clean and free from harmful segregations. Where considered necessary by the Surveyors these prints are to be supplemented by further prints from the cylindrical surfaces and by magnetic crack detection examinations or other approved tests.

### Surface-hardened and Case-hardened Pinions and Wheels

**822** Forgings for pinions and wheels of the above types are to comply generally with the manufacturing and inspection requirements of the preceding paragraphs and with the following test requirements.

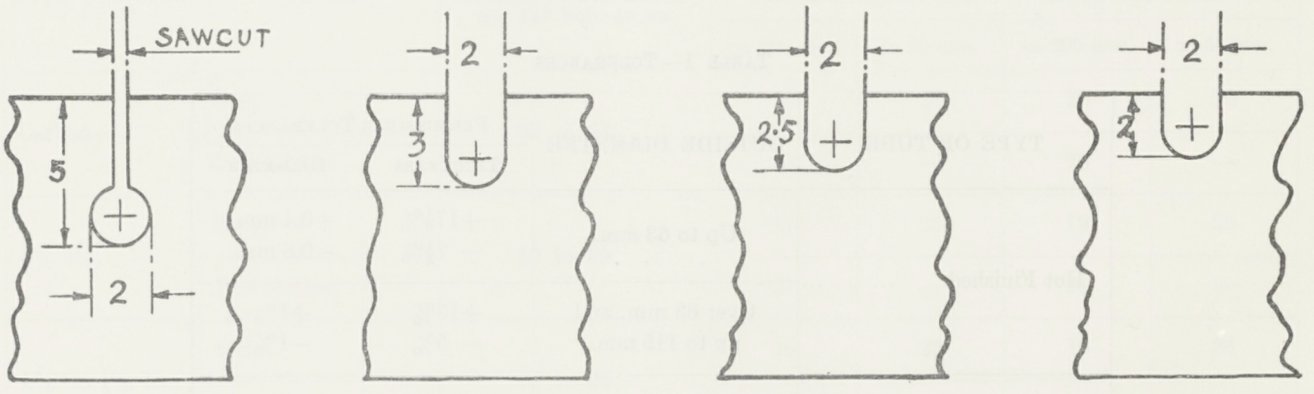
Tensile and impact tests are to be made to verify that the sub-surface mechanical properties comply with the approved specification. For surface-hardened parts these tests are to be made at the forge in accordance with requirements of 809 and 817: for case-hardened parts the forgings are to be inspected and identified at the forge and the tests made at the engine works or other agreed place after the gears are hardened and finally heat treated. Tests are to be provided as stated in 809 and 817, except that for pinions transverse tests from the body pieces will not be required.

Test blocks for case-hardened parts are to have dimensions such that they will be representative of the

TABLE 2—MECHANICAL PROPERTIES FOR WHEELS AND RIMS

| MATERIAL | HEAT TREATMENT | SPECIFIED MINIMUM TENSILE STRENGTH kg. per mm.² | MINIMUM YIELD STRESS kg. per mm.² | MINIMUM PERCENTAGE ELONGATION ON 50 mm. | BEND TEST RADIUS OF FORMER mm. | MINIMUM IMPACT VALUES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | kg. metres | kgm/cm.² | | | |
| | | | | | | Izod | Charpy Key-Hole | D.V.M. | V.S.M. | Mesnager |
| Carbon Steels | Normalised and tempered | 47 | 24 | 27 | 6,5 | Not applicable | | | | |
| | | 55 | 27 | 22 | 9,5 | | | | | |
| | | 63 | 31 | 20 | 16 | | | | | |
| | | 71 | 35 | 18 | 19 | | | | | |
| Alloy Steels | Normalised and tempered | 63 | 35 | 22 | Not applicable | * | * | * | * | * |
| | | 71 | 39 | 20 | | * | * | * | * | * |
| | | 79 | 43 | 18 | | * | * | * | * | * |
| | | 87 | 47 | 16 | | * | * | * | * | * |
| Alloy Steels | Oil-hardened and tempered | 63 | 44 | 23 | Not applicable | 4,8 | 6,7 | 7,8 | 7,8 | 8,7 |
| | | 71 | 52 | 22 | | 4,7 | 6,5 | 7,6 | 7,7 | 8,5 |
| | | 79 | 60 | 20 | | 4,4 | 6,2 | 7,2 | 7,3 | 8,0 |
| | | 87 | 69 | 18 | | 4,1 | 5,8 | 6,7 | 6,8 | 7,5 |
| | | 94 | 76 | 17 | | 3,9 | 5,5 | 6,3 | 6,4 | 7,1 |

* Impact tests are to be made and results recorded




CHARPY KEY-HOLE D.V.M. V.S.M. MESNAGER

The dimensions are in millimetres

forgings and for pinions they are to be not less in diameter than the journals. They are to be blank-carburised and heat treated with the pinion or wheel before being cut up for test purposes. The test pieces are to be cut from the blocks near the surface.

In addition to the aforementioned tensile and impact tests, hardness tests are to be made on the teeth, when hardened and ground, to verify that the surface hardness and sub-surface tensile strength of the teeth comply with the approved specification.

Where it is desired to adopt alternative tests to the foregoing, full details are to be submitted for consideration.

The teeth of all surface- and case-hardened pinions and wheels are to be examined for cracks and other imperfections by magnetic crack-detecting equipment or other approved means.

## Section 9

### BOILER TUBES AND PRESSURE PIPES

#### General

**901** The following requirements and tolerances are based generally on British practice. Alternative requirements and tolerances of British and other national standard specifications may be accepted where they provide reasonable equivalents to the requirements of this Section.

When the tubes or pipes are of a type or made from an alloy steel for which provision is not made in this Section, they will be required to comply with the terms of an approved specification or with such tests, appropriate to the material, as may be approved.

Requirements for wall thickness, permissible operating temperatures for different steels and service limitations for various types of tubes and pipes are given in the following paragraphs:—

E 508 to E 512—Steel pressure pipes.

J 1201 to J 1208—Smoke tubes and other tubes for cylindrical boilers.

J 1402 & J 1403, J 1615 & J 1616—Boiler, superheater and downcomer tubes for water tube boilers.

**902** The steel is to be made by the open hearth, electric furnace or other approved process, and is to show on analysis not more than 0,05 per cent sulphur or phosphorus.

**903** Where the designed operating metal temperature exceeds 400° C., the steel, whether carbon or alloy, is to be of the non-segregated and fully killed type. In order to avoid intergranular penetration by non-ferrous metals, tubes or pipes of alloy steel are not to come into contact with such metals or their compounds during manufacture.

A certificate giving the chemical analysis of the steel for each cast is to be provided for all tubes and pipes.

**904** Cold drawn carbon steel tubes or pipes are to be annealed or normalised after drawing. Low alloy molybdenum and chromium molybdenum steel tubes or pipes are to be annealed or normalised; other alloy steel tubes or pipes are to be given a heat treatment suitable for the materials concerned.

**905** All tubes and pipes are to be smooth and practically concentric throughout their length and are to be examined externally and internally and be free from defects. Ends are to be ground where necessary to facilitate examination.

TABLE 1—TOLERANCES

| TYPE OF TUBE | OUTSIDE DIAMETER | PERMISSIBLE TOLERANCES | |
|---|---|---|---|
| | | THICKNESS | DIAMETER |
| Hot Finished ... ... | Up to 63 mm. | +17½%<br>− 7½% | +0,4 mm.<br>−0,8 mm. |
| | Over 63 mm. and up to 115 mm. | +15%<br>− 5% | +1%<br>−1% |
| Cold Drawn ... ... | All sizes | +10%<br>− 5% | +0<br>−1% |

**Boiler Tubes.** (Smoke tubes, water tubes and superheater tubes.)

**906** Tubes for water tube boilers and superheaters are to be seamless unless otherwise specially approved; those under 38 mm. external diameter are to be cold drawn.

**907** Tolerances on thickness and diameter of straight tubes are not to exceed those given in Table 1.

**908** Every tube is to be tested, at the makers' works, by hydraulic pressure to the requirements of Table 2.

The makers' certificate of hydraulic test may be accepted.

**909** Tubes of the same diameter, thickness and material are to be presented for mechanical testing in batches of 100 tubes. Two tubes are to be selected indiscriminately from at least two of the batches and one tube from each remaining batch. The selected tubes are to be subjected to tensile, flattening and expanding tests, as detailed in the following paragraphs.

TABLE—2 HYDRAULIC TEST PRESSURES

| WORKING PRESSURE KG. PER SQUARE CM. | HYDRAULIC TEST PRESSURE KG. PER SQUARE CM. |
|---|---|
| Up to and including 35 ... | 70 |
| Over 35 up to and including 70 | 2 × working pressure |
| Over 70 ... ... ... | Working pressure + 70 |

**910** Tensile test pieces may be strips cut from the tubes or lengths of full section tube. In the case of hot finished tubes where the tube ends only have been annealed the test pieces are to be taken from the un-annealed portion of the tube. The mechanical properties are to comply with the requirements of Table 3.

**911** Expanding tests are to be made on both ends of all selected tubes using a drift expander having a total included angle of from 40°–60°. The tube ends are to withstand when cold and without signs of cracking the increases in diameter given in Table 4.

**912** Flattening tests are to be made on one selected tube from each batch. This tube is to withstand being flattened when cold and without cracking, to the extent given in Table 4, at three different positions; one position is to be near the middle of the length and all are to be in different planes.

**913** Should one of the selected tubes fail to comply with any one or more of the tests specified in 910 to 912, two further tests of the same kind are to be made on two additional tubes selected from the same batch. If failure again occurs the batch of tubes is to be rejected as unsatisfactory.

**Pressure Pipes**

**914** Pipes may be seamless, or of other approved type as required in E 509 to E 511, according to the service for which they are intended.

**915** Tolerances on thickness and diameter of straight pipes are not to exceed those given in Table 5.

TABLE 3—MECHANICAL PROPERTIES

| TYPE OF STEEL | TYPE OF TEST PIECE | RANGE OF TENSILE BREAKING STRENGTH, KG. PER SQUARE MM. | MINIMUM ELONGATION, PER CENT | | | |
|---|---|---|---|---|---|---|
| | | | Less than 6,4 mm. thick | | 6,4 mm. thick and over | |
| | | | on 200 mm. | on 50 mm. | on 200 mm. | on 50 mm. |
| Carbon | Strip | 32 to 44 | 18 | 28 | 20 | 30 |
| | Full section | | 23 | — | 25 | — |
| ½% Mo. | Strip | 40 to 55 | 17 | 23 | 19 | 25 |
| | Full section | | 21 | — | 23 | — |
| 1% Cr. ½% Mo. | Strip | 43 to 58 | 16 | 22 | 18 | 24 |
| | Full section | | 20 | — | 22 | — |

TABLE 4—EXPANDING AND FLATTENING TESTS

| THICKNESS OF TUBE MILLIMETRES. | EXPANDING TEST | | FLATTENING TEST | | |
|---|---|---|---|---|---|
| | Increase in O.D. per cent | | Distance apart of inner surfaces | | |
| | | | Carbon Steel | | Alloy Steel |
| | Carbon Steel | Alloy Steel | Cold Drawn | Hot Finished | |
| Up to 3,25 ... ... ... ... | 15 | 12½ | Touching | 3 times the thickness | |
| Over 3,25 and up to 4,9 ... ... | | 9½ | 2 times the thickness | | |
| Over 4,9 and up to 6,4 ... ... | 12 | 6½ | | | |
| Over 6,4 ... ... ... ... | 9½ | | | | |

TABLE 5—TOLERANCES FOR SEAMLESS PIPES

| TYPE OF PIPE | PERMISSIBLE TOLERANCES | | | | | |
|---|---|---|---|---|---|---|
| | THICKNESS | | OUTSIDE DIAMETER | | BORE | |
| | $t/D \leq 3\%$ | $t/D > 3\%$ | up to 48,5 mm. O.D. | Over 48,5 mm. O.D. | Under 153 mm. bore | 153 mm. bore and over |
| Hot Finished | +15%<br>−15% | +12½%<br>−12½% | +0,4 mm.<br>−0,8 mm. | +1%<br>−1% | — | — |
| Cold Drawn | +10%<br>−10% | | — | — | +1%<br>−1% | +0,8 mm.<br>−1,6 mm. |

**916** Every pipe, while straight and with plain ends, is to be hydraulically tested at the makers' works to the pressure derived from the formula given below or to 70 kg. per square cm. whichever is less.

For Seamless Carbon and Alloy Steels

$$\text{Test Pressure} = t/D \times S \times 54$$

Where $t$ = nominal thickness, in millimetres.
$D$ = nominal outside diameter, in millimetres.
$S$ = minimum tensile breaking strength, in kg. per square mm.

The makers' certificate of hydraulic test may be accepted.

**917** Mechanical tests are to be taken in the following proportions from pipes of the same diameter and thickness and from the same cast.

Up to and including 115 mm. O.D....1 in 40 or part thereof
Over 115 mm. and up to 153 mm. O.D....1 in 10 or part thereof
Over 153 mm. O.D. ... ... ...1 in 5 or part thereof

The mechanical tests required are a tensile test and either a flattening or bend test. Flattening tests are to be made on pipes up to 115 mm. O.D. and bend tests on pipes over 115 mm. O.D.

**918** Tensile test pieces may be strips cut from the pipes or lengths of full section pipe. The mechanical properties are to comply with the requirements of Table 6.

**919** A flattening test, on pipes up to 115 mm. O.D., is to be made on a ring not less than 38 mm. long, cut from one end of each selected pipe. This ring is to

TABLE 6—MECHANICAL PROPERTIES

| TYPE OF STEEL | TYPE OF TEST PIECE | RANGE OF TENSILE BREAKING STRENGTH, KG. PER SQUARE MM. | MINIMUM ELONGATION, PER CENT | | | |
|---|---|---|---|---|---|---|
| | | | Less than 6,4 mm. thick | | 6,4 mm. thick and over | |
| | | | on 200 mm. | on 50 mm. | on 200 mm. | on 50 mm. |
| Carbon | Strip | 36 to 47 | 18 | 28 | 20 | 30 |
| | Full section | | 23 | — | 25 | — |
| ½% Mo. | Strip | 40 to 55 | 17 | 23 | 19 | 25 |
| | Full section | | 21 | — | 23 | — |
| 1% Cr. ½% Mo. | Strip | 43 to 58 | 16 | 22 | 18 | 24 |
| | Full section | | 20 | — | 22 | — |

withstand being flattened, when cold and without cracking, until the distance apart of the inner surfaces of the pipe is 4 times its thickness or ⅔ of the bore, whichever is less.

**920** A bend test on pipes over 115 mm. O.D., is to be made on a strip not less than 38 mm. wide cut circumferentially from one end of each selected pipe. This strip is to withstand being bent double in the direction of original curvature, when cold and without cracking, over a round bar or former of diameter as follows:—

Up to 9,5 mm. thickness... 3 times the pipe thickness
Over 9,5 mm. thickness.... 4 times the pipe thickness or ⅔ of the bore whichever is less.

**921** Should a pipe selected for testing fail to comply with any one or more of the tests specified in 918 to 920 two further tests of the same kind are to be made from another pipe from the same batch. If failure again occurs the batch of pipes is to be rejected as unsatisfactory.

## Section 10

## BRONZE PROPELLERS AND PROPELLER BLADES

### General

**1001** The requirements of this section are applicable to propeller castings of the following non-ferrous materials:—

(a) Manganese bronze or high tensile brass with a minimum tensile strength of 44 kg. per mm.²

(b) High tensile aluminium bronzes with a minimum tensile strength of 63 kg. per mm.²

Particulars of chemical composition and mechanical properties of proprietary alloys are to be submitted for information.

**1002** Where it is proposed to use other non-ferrous materials or different grades of type (a) and (b) alloys, full particulars are to be submitted for consideration.

**1003** Castings are to be clean and free from harmful defects and are to be tested and inspected at the makers' works. In the event of any casting proving defective in the course of subsequent machining such casting may be rejected notwithstanding any previous certification of satisfactory test.

### Provision of Test Samples

**1004** Test samples, sufficient for the preparation of at least three test pieces, are to be provided for each casting. The test samples are to be of approved form and may be separately-cast or integral with the casting.

**1005** Separately-cast test samples:— These may be adopted at works where Surveyors are in frequent attendance. The procedure for identifying the test samples and the propeller casting is to be approved by the Surveyors who in cases of doubt may require that check analyses of sample and casting be made.

The samples are to be separately cast at the same time and from the same metal as the casting which they represent, and are to be poured into moulds of the same material as that used for the casting. Where a casting is made from more than one ladle test samples are to be provided for each ladle.

**1006** Integral test samples:— These are to be provided as blocks cast on the surfaces of the casting. Samples gated from the casting are not acceptable.

NOTE.—With the object of obtaining sound test blocks and of permitting free contraction of the propeller casting, it is preferable that the test blocks be arranged axially on the hub instead of on the blades at mid-radii.

### Mechanical Properties

**1007** Test pieces are to be 14 mm. diameter with a gauge length of 50 mm. or of other similar standard. At least one tensile test is to be made for each casting and for each ladle if 1005 is applicable. The test results are to comply with the requirements of the following table or of a specification specially approved.

If the first test piece fails to meet requirements, then the two remaining test pieces are to be broken; if these also fail the casting is to be rejected.

| Material | Minimum Tensile Strength kg. per mm.² | | Minimum Elongation per cent on 50 mm. gauge length |
|---|---|---|---|
| | Integral test piece | Separately-cast test piece | |
| (a) Manganese Bronze | 44 | 47 | 20 |
| (b) Aluminium Bronze | 63 | 66 | 15 |

NOTE.—The values in the table are applicable to test pieces and are not necessarily obtainable from all parts of the castings. In general it can be expected that the mechanical properties of a propeller, especially in the thick root sections of the blades, will be inferior to those of the test piece.

## Section 11

## ANCHORS

### Process of Manufacture

**1101** Anchors are to be made of forged ingot steel or cast steel. Forged steel anchors are to be manufactured in accordance with the relevant requirements of P 6. The carbon content of the steel is not to exceed 0,25 per cent, other elements in the steel being restricted in accordance with P 604. When the weight of the forging exceeds 3000 kg., it is to be heat treated by normalising. The tensile strength of forged carbon steel anchors is not to exceed 52 kg. per mm.² The manufacturing process of cast steel anchors is to comply with the relevent requirements of P 5. Forged and cast steel anchor heads and cast steel shanks are to be subjected to the test requirements of these sections except that the percussive and hammering tests detailed in P 12 are to be substituted for the requirements of P 512, P 513 and P 514.

Where, however, more than one anchor head is poured from a charge one tensile and one bend test per charge will be accepted, provided all anchor heads from the charge are heat treated at the same time and under the same conditions. If the weight of a charge exceeds 3000 kg. and more than one anchor is poured from the charge, a further tensile and bend test should be taken.

**1102** Each important part of an anchor is to be plainly marked by the maker with the words "forged ingot steel" or "heat treated cast steel" as the case may be (or simply "forged steel" or "cast steel").

**1103** Steel anchor shackles are to be made of forged ingot steel or cast steel as specified in 1101, but need not be submitted to the test requirements of P 5 and P 6.

### Proof Tests of Anchors

**1104** All anchors weighing more than 76 kg. inclusive of stock, if fitted, are to be tested in accordance with the requirements of the following table and the certificates of test produced.

## Proof Tests for Anchors

| Weight | Test | Weight | Test | Weight | Test | Weight | Test | Weight | Test | Weight | Test |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Kg. | Kg. | Kg. | Kg. | Kg. | Kg. | Kg. | Kg. | Kg. | Kg. | Kg. | Kg. |
| 75 | 4000 | 540 | 12750 | 1200 | 24000 | 3700 | 56050 | 6200 | 76600 | 8700 | 91000 |
| 80 | 4100 | 560 | 13150 | 1300 | 25700 | 3800 | 57050 | 6300 | 77250 | 8800 | 91500 |
| 90 | 4300 | 580 | 13550 | 1400 | 27250 | 3900 | 58050 | 6400 | 77850 | 8900 | 92000 |
| 100 | 4550 | 600 | 13950 | 1500 | 28750 | 4000 | 58950 | 6500 | 78500 | 9000 | 92500 |
| 120 | 4950 | 620 | 14300 | 1600 | 30250 | 4100 | 59800 | 6600 | 79100 | 9100 | 93000 |
| 140 | 5350 | 640 | 14650 | 1700 | 31750 | 4200 | 60800 | 6700 | 79750 | 9200 | 93500 |
| 160 | 5700 | 660 | 15000 | 1800 | 33250 | 4300 | 61800 | 6800 | 80350 | 9300 | 94000 |
| 180 | 6100 | 680 | 15300 | 1900 | 34600 | 4400 | 62750 | 6900 | 81000 | 9400 | 94500 |
| 200 | 6450 | 700 | 15700 | 2000 | 35950 | 4500 | 63550 | 7000 | 81600 | 9500 | 95000 |
| 220 | 6850 | 720 | 16050 | 2100 | 37300 | 4600 | 64500 | 7100 | 82200 | 9600 | 95500 |
| 240 | 7250 | 740 | 16400 | 2200 | 38750 | 4700 | 65300 | 7200 | 82850 | 9700 | 96000 |
| 260 | 7600 | 760 | 16750 | 2300 | 40050 | 4800 | 66250 | 7300 | 83500 | 9800 | 96500 |
| 280 | 7950 | 780 | 17100 | 2400 | 41300 | 4900 | 67000 | 7400 | 84100 | 9900 | 97000 |
| 300 | 8300 | 800 | 17450 | 2500 | 42550 | 5000 | 67750 | 7500 | 84750 | 10000 | 97500 |
| 320 | 8700 | 820 | 17800 | 2600 | 43800 | 5100 | 68500 | 7600 | 85350 | 10500 | 99800 |
| 340 | 9100 | 840 | 18150 | 2700 | 45050 | 5200 | 69250 | 7700 | 85900 | 11000 | 101950 |
| 360 | 9500 | 860 | 18500 | 2800 | 46200 | 5300 | 70000 | 7800 | 86450 | 11500 | 103950 |
| 380 | 9850 | 880 | 18800 | 2900 | 47450 | 5400 | 70750 | 7900 | 86950 | 12000 | 105900 |
| 400 | 10200 | 900 | 19100 | 3000 | 48550 | 5500 | 71500 | 8000 | 87450 | 12500 | 107900 |
| 420 | 10600 | 920 | 19400 | 3100 | 49700 | 5600 | 72250 | 8100 | 88000 | 13000 | 109900 |
| 440 | 11000 | 940 | 19750 | 3200 | 50800 | 5700 | 73000 | 8200 | 88500 | 13500 | 111900 |
| 460 | 11400 | 960 | 20100 | 3300 | 51800 | 5800 | 73750 | 8300 | 89000 | 14000 | 113900 |
| 480 | 11700 | 980 | 20450 | 3400 | 52800 | 5900 | 74500 | 8400 | 89500 | 14500 | 115900 |
| 500 | 12050 | 1000 | 20800 | 3500 | 54050 | 6000 | 75250 | 8500 | 90000 | 15000 | 117900 |
| 520 | 12400 | 1100 | 22550 | 3600 | 55050 | 6100 | 76000 | 8600 | 90500 | 15500 | 119900 |

The weight given in the above Table is either for stockless anchors or for stocked anchors without the stock.
For intermediate weights the test may be obtained by interpolation.

## Section 12

### CAST STEEL ANCHORS

#### General

**1201** All cast steel anchors are to be subjected to the percussive and hammering tests as detailed in this Section.

#### Percussive Test

**1202** The anchor, or where anchors are made in more than one piece, each piece is to be raised a given height and then dropped on a steel or iron slab.

For weights of 760 kg. and below, the height is to be 4,60 metres and for weights above 760 kg. the height is to be 3,65 metres.

The lowest part of the anchor or piece when suspended is to be at least the given height above the slab upon which it is to be dropped.

**1203** An anchor of the Admiralty pattern is first to be raised vertically to the given height with its shank and arms in a horizontal position, and then let fall from that height.

It is then to be raised a second time to the given height and suspended with the crown downwards. Two steel or iron blocks are to be placed underneath it, and the anchor is to be let fall from this position so that one of the blocks receives it on the middle of one arm, and the other block receives it on the middle of the other arm.

**1204** The slab for the horizontal test is to be of steel or iron, well laid on a solid concrete foundation to the satisfaction of the Surveyor.

**1205** The blocks for the vertical test are to be solid and of sufficient height to prevent the crown of the anchor from touching the slab, and are to be to the satisfaction of the Surveyor.

#### Hammering Test

**1206** Provided the percussive test has been satisfactory, the anchor or piece is to be slung and thoroughly hammered over its parts with a sledge hammer weighing not less than 3 kg., and is required to give under this treatment such a clear ring in all its parts as shall satisfy the Surveyor that the casting is sound and that no flaws have developed by the application of the preceding percussive tests.

## Section 13

### CHAIN CABLES AND STEERING CHAINS

*Note:—For list of manufacturers of electrically welded and cast steel chain cables see Appendix to this Chapter.*

#### General

**1301** Chain cables or steering gear chains may be of any one of the following grades:—

| Grade | Method of Manufacture | Material |
|---|---|---|
| I (a) | Fire welded | Wrought iron |
| I (b) | Fire welded | Mild steel U.T.S. 31,5–41 kg. per mm.$^2$ |
| I (c) | Flash butt welded | Mild steel U.T.S. 31,5–41 kg. per mm.$^2$ |
| II | Flash butt welded | Mild steel U.T.S. 41–50 kg. per mm.$^2$ |
| III (a) | Flash butt welded or drop forged | Special steel U.T.S. 50–63 kg. per mm.$^2$ |
| III (b) | Cast | Cast steel U.T.S. 50–63 kg. per mm.$^2$ |

Methods of manufacture and materials other than those given above will be specially considered.

"Special steel" cable referred to in Table 53 (Equipment) is cable complying with the material and testing requirements for Grades III (a) or (b).

#### Initial Approval of Method of Manufacture

**1302** For all grades other than I (a) or I (b) the method of manufacture is to be approved and the requisite preliminary tests carried out.

**1303** Approval tests for a higher grade cover lower grades (up to the same diameter) provided the method of manufacture and heat treatment are generally the same.

#### Material Test

**1304** Composition. Rolled bar material is to be made at an Approved Works and is to comply with P 1 so far as applicable. The chemical composition is to be as required for Grade A Steel.

Tensile and bend test pieces representative of each cast are to be prepared at the steelworks and tested in the presence of the Surveyor. Unless otherwise agreed, the

material for these tests is not to be heat treated after removal from the rolled bars.

The chemical composition of cast steel cables will be specially considered.

**1305** NUMBER OF TESTS. Two tensile and two bend test pieces are to be taken from each cast unless the weight of finished material exceeds 20000 kg. when one additional set of tensile and bend tests is to be taken from each further 10000 kg. or fraction thereof. Where bars of different diameters are rolled from the same cast the test material selected shall be representative of the largest and smallest sizes.

**1306** TENSILE TESTS. These may be either the full section as rolled or may be machined to a convenient size provided the area of the reduced portion is not less than 3,2 cm.$^2$. Any of the gauge lengths given in Table 1 may be used.

The tensile strength of the material is to be within the limits specified in 1301 for the grade of cable for which the bars are intended. The percentage elongation is not to be less than that given in Table 1.

**1307** BEND TESTS. These may be either the full section as rolled or may be machined to a diameter of not less than 25,5 mm. Each test piece is to withstand, without fracture, cold bending through an angle of 180° over a former with a maximum radius as given in Table 1.

TABLE 1

| Tensile Strength | Minimum percentage elongation | | | Max. radius of former for bend test |
|---|---|---|---|---|
| | Gauge Length | | | |
| kg. per mm.$^2$ | 8 × dia. | $4\sqrt{A}$ | $5{,}65\sqrt{A}$ | |
| 31,5–41 | 25 | 34 | 30 | 1 × d |
| 41 –50 | 20 | 29 | 25 | 1 × d |
| 50 –63 | 15 | 23 | 19 | 1½ × d |

A = area of cross-section of test piece,
d = diameter of test piece.

### Heat Treatment

**1308** All steel cables, except grades I (b) and I (c), are to be given a suitable refining heat treatment on completion of manufacture and before applying the proof and breaking loads. For flash butt welded cables the heat treatment is to consist of normalising.

### Testing of Chains

**1309** All chain cables and steering chains are to be tested at a proving establishment recognised by the Committee (*see* D 3306). When the (United Kingdom) Anchors and Chain Cables Act applies* the cables are to be tested at a Licensed Proving House in the United Kingdom.

**1310** BREAKING TEST. Three link samples are to be selected by the Surveyor as required by Table 2 and subjected to the breaking load given in Tables 3A or 4. When the (United Kingdom) Anchors and Chain Cables Act applies one three-link sample is to be taken from every 15 fathoms (or less) length and the breaking load is to be as given in Tables 3B or 4.

*NOTE.—The Anchors and Chain Cables Act 1899 applies to chain cables bought or sold in the United Kingdom for use on a British ship.

TABLE 2

| Grade | Diameter | Number of Samples |
|---|---|---|
| I | All diameters | 1 from each 27,5 metre length |
| II and III (a) | Not exceeding 40 mm. | 1 from every two 27,5 metre lengths or less |
| | Exceeding 40 mm. | 1 from every four 27,5 metre lengths or less |
| III (b) | All diameters | 1 from each 27,5 metre length |

**1311** PROOF TEST. Every length is to be subjected to the proof load given in Tables 3A, 3B, or 4 as appropriate.

**1312** EXAMINATION. After being subjected to the proof test all chain cables are to be thoroughly examined.

**1313** SHACKLES. End and joining shackles are to be subjected to the breaking and proof loads appropriate to the grade of cable for which they are intended. The breaking load shall be applied to at least one shackle out of 25 (1 in 50 for lugless shackles).

For wrought iron shackles, the shackle which has satisfactorily withstood the breaking load shall be subjected to a ductility test by opening it, while cold, until its sides are at an angle of 45° to each other and then closing it until the sides are again parallel.

Drop forged, cast steel and lugless shackles are to be manufactured to an agreed specification and tensile and

TABLE 3A—STUD LINK CHAIN CABLE

| Diameter | GRADE | | | | | | Minimum weight per length of 27,5 metres | |
|---|---|---|---|---|---|---|---|---|
| | I | | II | | III | | | |
| | Proof Load | Breaking Load | Proof Load | Breaking Load | Proof Load | Breaking Load | With Dee Shackle | With Lugless Shackle |
| mm. | kg. | kg. | kg. | kg. | kg. | kg. | kg. | kg. |
| 11 | 3380 | 5050 | 3380 | 5050 | 4760 | 7030 | 85 | 83 |
| 12 | 4080 | 6120 | 4080 | 6120 | 5740 | 8600 | 100 | 98 |
| 13 | 4780 | 7160 | 4780 | 7160 | 6700 | 10100 | 115 | 112 |
| 14 | 5490 | 8230 | 5490 | 8230 | 7740 | 11500 | 130 | 127 |
| 15 | 6310 | 9390 | 6310 | 9390 | 8850 | 13200 | 145 | 142 |
| 16 | 7230 | 10700 | 7230 | 10700 | 10100 | 15200 | 160 | 157 |
| 17 | 8190 | 12200 | 8190 | 12200 | 11500 | 17300 | 180 | 177 |
| 18 | 9120 | 13800 | 9120 | 13800 | 12900 | 19300 | 200 | 196 |
| 19 | 10100 | 15400 | 10100 | 15400 | 14400 | 21400 | 220 | 216 |
| 20 | 11300 | 17000 | 11300 | 17000 | 15900 | 23800 | 240 | 236 |
| 21 | 12500 | 18700 | 12500 | 18700 | 17500 | 26200 | 265 | 261 |
| 22 | 13700 | 20500 | 13700 | 20500 | 19200 | 28800 | 290 | 286 |
| 23 | 15000 | 22400 | 15000 | 22400 | 21000 | 31500 | 320 | 315 |
| 24 | 16300 | 24400 | 16300 | 24400 | 22800 | 34200 | 350 | 345 |
| 25 | 17700 | 26500 | 17700 | 26500 | 24800 | 37200 | 380 | 375 |
| 26 | 19200 | 28700 | 19200 | 28700 | 26800 | 40300 | 410 | 405 |
| 27 | 20600 | 30900 | 20600 | 30900 | 28900 | 43300 | 445 | 440 |
| 28 | 22200 | 33100 | 22200 | 33100 | 31100 | 46600 | 480 | 475 |
| 29 | 23800 | 35500 | 23800 | 35500 | 33400 | 50000 | 515 | 510 |
| 30 | 25500 | 38100 | 25500 | 38100 | 35600 | 53500 | 550 | 545 |
| 31 | 27200 | 40800 | 27200 | 40800 | 38100 | 57100 | 585 | 580 |
| 32 | 29100 | 43500 | 29100 | 43500 | 40700 | 61100 | 620 | 615 |
| 33 | 30900 | 46300 | 30900 | 46300 | 43200 | 64900 | 660 | 650 |
| 34 | 32700 | 49100 | 32700 | 49100 | 45800 | 68700 | 700 | 690 |
| 35 | 34700 | 52100 | 34700 | 52100 | 48500 | 72400 | 740 | 730 |
| 36 | 36700 | 55200 | 36700 | 55200 | 51200 | 77100 | 785 | 775 |
| 37 | 38700 | 57500 | 38700 | 57500 | 53900 | 80700 | 830 | 820 |
| 38 | 40800 | 59500 | 40800 | 59500 | 57200 | 83300 | 875 | 860 |
| 39 | 43000 | 61300 | 43000 | 61300 | 60300 | 85700 | 920 | 905 |
| 40 | 45300 | 63400 | 45300 | 63400 | 63400 | 88500 | 965 | 950 |
| 41 | 47600 | 66600 | 47600 | 66600 | 66600 | 93100 | 1010 | 995 |
| 42 | 50000 | 70000 | 50000 | 70000 | 70000 | 98000 | 1055 | 1040 |
| 43 | 52400 | 73400 | 52400 | 73400 | 73400 | 103000 | 1100 | 1080 |
| 44 | 54900 | 76800 | 54900 | 76800 | 76800 | 108000 | 1150 | 1130 |
| 45 | 57400 | 80400 | 57400 | 80400 | 80400 | 113000 | 1205 | 1185 |

(*See Continuation*)

TABLE 3A—STUD LINK CHAIN CABLE (*Continued*)

| Diameter | GRADE | | | | | | Minimum weight per length of 27,5 metres | |
|---|---|---|---|---|---|---|---|---|
| | I | | II | | III | | | |
| | Proof Load | Breaking Load | Proof Load | Breaking Load | Proof Load | Breaking Load | With Dee Shackle | With Lugless Shackle |
| mm. | kg. | kg. | kg. | kg. | kg. | kg. | kg. | kg. |
| 46 | 60000 | 84100 | 60000 | 84100 | 84100 | 118000 | 1260 | 1240 |
| 47 | 62600 | 87800 | 62600 | 87800 | 87800 | 123000 | 1315 | 1290 |
| 48 | 65300 | 91300 | 65300 | 91300 | 91300 | 128000 | 1370 | 1345 |
| 49 | 68000 | 95200 | 68000 | 95200 | 95200 | 133000 | 1425 | 1400 |
| 50 | 70800 | 99300 | 70800 | 99300 | 99300 | 139000 | 1485 | 1455 |
| 51 | 73700 | 103000 | 73700 | 103000 | 103000 | 144000 | 1545 | 1515 |
| 52 | 76700 | 107000 | 76700 | 107000 | 107000 | 150000 | 1605 | 1575 |
| 53 | 79600 | 111000 | 79600 | 111000 | 111000 | 156000 | 1665 | 1630 |
| 54 | 82600 | 116000 | 82600 | 116000 | 116000 | 162000 | 1725 | 1690 |
| 55 | 85700 | 120000 | 85700 | 120000 | 120000 | 167000 | 1785 | 1745 |
| 56 | 88800 | 124000 | 88800 | 124000 | 124000 | 173000 | 1850 | 1810 |
| 57 | 92200 | 129000 | 92200 | 129000 | 129000 | 180000 | 1915 | 1875 |
| 58 | 95400 | 133000 | 95400 | 133000 | 133000 | 187000 | 1985 | 1945 |
| 59 | 98700 | 138000 | 98700 | 138000 | 138000 | 193000 | 2055 | 2010 |
| 60 | 102000 | 143000 | 102000 | 143000 | 143000 | 200000 | 2125 | 2075 |
| 61 | 105000 | 148000 | 105000 | 148000 | 148000 | 206000 | 2200 | 2150 |
| 62 | 109000 | 152000 | 109000 | 152000 | 152000 | 213000 | 2275 | 2220 |
| 63 | 113000 | 158000 | 113000 | 158000 | 158000 | 221000 | 2350 | 2295 |
| 64 | 116000 | 162000 | 116000 | 162000 | 162000 | 227000 | 2430 | 2370 |
| 65 | 118000 | 166000 | 119000 | 167000 | 167000 | 234000 | 2510 | 2450 |
| 66 | 121000 | 169000 | 122000 | 171000 | 171000 | 240000 | 2590 | 2525 |
| 67 | 124000 | 173000 | 126000 | 176000 | 176000 | 246000 | 2670 | 2600 |
| 68 | 126000 | 177000 | 129000 | 181000 | 181000 | 253000 | 2755 | 2685 |
| 69 | 129000 | 181000 | 133000 | 186000 | 186000 | 260000 | 2840 | 2765 |
| 70 | 132000 | 184000 | 136000 | 191000 | 191000 | 267000 | 2925 | 2850 |
| 71 | 134000 | 188000 | 140000 | 195000 | 195000 | 274000 | 3010 | 2930 |
| 72 | 137000 | 192000 | 143000 | 200000 | 200000 | 281000 | 3095 | 3010 |
| 73 | 140000 | 196000 | 147000 | 206000 | 206000 | 288000 | 3185 | 3100 |
| 74 | 142000 | 199000 | 151000 | 211000 | 211000 | 295000 | 3275 | 3185 |
| 75 | 145000 | 203000 | 154000 | 216000 | 216000 | 302000 | 3370 | 3275 |
| 76 | 148000 | 207000 | 158000 | 221000 | 221000 | 310000 | 3460 | 3360 |
| 77 | 150000 | 210000 | 162000 | 226000 | 226000 | 317000 | 3550 | 3445 |
| 78 | 153000 | 214000 | 166000 | 232000 | 232000 | 325000 | 3640 | 3535 |
| 79 | 155000 | 217000 | 170000 | 238000 | 238000 | 333000 | 3740 | 3630 |
| 80 | 158000 | 221000 | 174000 | 243000 | 243000 | 340000 | 3840 | 3725 |

(*See Continuation*)

TABLE 3A—STUD LINK CHAIN CABLE (*Continued*)

| Diameter | GRADE | | | | | | Minimum weight per length of 27,5 metres | |
|---|---|---|---|---|---|---|---|---|
| | I | | II | | III | | | |
| | Proof Load | Breaking Load | Proof Load | Breaking Load | Proof Load | Breaking Load | With Dee Shackle | With Lugless Shackle |
| mm. | kg. | kg. | kg. | kg. | kg. | kg. | kg. | kg. |
| 81 | 160000 | 224000 | 178000 | 249000 | 249000 | 348000 | 3940 | 3820 |
| 82 | 163000 | 228000 | 182000 | 255000 | 255000 | 356000 | 4040 | 3915 |
| 83 | 165000 | 231000 | 186000 | 260000 | 260000 | 365000 | 4140 | 4010 |
| 84 | 168000 | 235000 | 190000 | 266000 | 266000 | 373000 | 4240 | 4105 |
| 85 | 170000 | 238000 | 194000 | 272000 | 272000 | 381000 | 4345 | 4205 |
| 86 | 172000 | 242000 | 199000 | 278000 | 278000 | 389000 | 4450 | 4305 |
| 87 | 175000 | 245000 | 203000 | 284000 | 284000 | 398000 | 4555 | 4405 |
| 88 | 177000 | 249000 | 207000 | 290000 | 290000 | 407000 | 4660 | 4505 |
| 89 | 180000 | 251000 | 212000 | 297000 | 297000 | 415000 | 4765 | 4605 |
| 90 | 182000 | 254000 | 216000 | 303000 | 303000 | 424000 | 4870 | 4705 |
| 91 | 184000 | 257000 | 221000 | 309000 | 309000 | 433000 | 4975 | 4805 |
| 92 | 186000 | 260000 | 226000 | 316000 | 316000 | 442000 | 5080 | 4905 |
| 93 | 188000 | 263000 | 230000 | 322000 | 322000 | 451000 | 5185 | 5005 |
| 94 | 190000 | 266000 | 235000 | 329000 | 329000 | 460000 | 5295 | 5110 |
| 95 | 192000 | 269000 | 240000 | 335000 | 335000 | 470000 | 5405 | 5210 |
| 96 | 194000 | 272000 | 244000 | 342000 | 342000 | 479000 | 5515 | 5315 |
| 97 | 196000 | 275000 | 249000 | 349000 | 349000 | 488000 | 5625 | 5420 |
| 98 | 198000 | 277000 | 254000 | 356000 | 356000 | 498000 | 5740 | 5530 |
| 99 | 200000 | 280000 | 259000 | 363000 | 363000 | 508000 | 5855 | 5635 |
| 100 | 202000 | 283000 | 264000 | 370000 | 370000 | 518000 | 5970 | 5745 |
| 101 | 204000 | 285000 | 269000 | 377000 | 377000 | 527000 | 6090 | 5860 |
| 102 | 205000 | 288000 | 274000 | 384000 | 384000 | 537000 | 6210 | 5970 |
| 103 | 207000 | 290000 | 279000 | 391000 | 391000 | 547000 | 6330 | 6085 |
| 104 | 209000 | 292000 | 285000 | 398000 | 398000 | 558000 | 6455 | 6205 |
| 105 | 210000 | 294000 | 290000 | 406000 | 406000 | 568000 | 6580 | 6320 |
| 106 | 212000 | 297000 | 295000 | 413000 | 413000 | 578000 | 6710 | 6445 |
| 107 | 213000 | 299000 | 300000 | 421000 | 421000 | 589000 | 6840 | 6565 |
| 108 | 215000 | 301000 | 306000 | 428000 | 428000 | 599000 | 6975 | 6695 |
| 109 | 216000 | 302000 | 311000 | 436000 | 436000 | 610000 | 7110 | 6820 |
| 110 | 217000 | 304000 | 317000 | 443000 | 443000 | 621000 | 7245 | 6950 |
| 111 | 219000 | 306000 | 322000 | 451000 | 451000 | 632000 | 7380 | 7080 |
| 112 | 220000 | 308000 | 328000 | 459000 | 459000 | 643000 | 7520 | 7210 |
| 113 | 221000 | 309000 | 334000 | 467000 | 467000 | 654000 | 7660 | 7340 |
| 114 | 222000 | 311000 | 339000 | 475000 | 475000 | 665000 | 7805 | 7480 |

TABLE 3B (INCH UNITS)—STUD LINK CHAIN CABLE

(Subject to Anchors and Chain Cables Act)

| Diameter | GRADE | | | | Minimum weight per length of 15 fathoms | |
|---|---|---|---|---|---|---|
| | I and II | | III | | | |
| | Proof Load | Breaking Load | Proof Load | Breaking Load | With Dee Shackle | With Lugless Shackle |
| Inches | Tons | Tons | Tons | Tons | Cwts. | Cwts. |
| 7/16 | 3·40 | 5·10 | 4·80 | 7·10 | 1¾ | 1 11/16 |
| ½ | 4·50 | 6·75 | 6·30 | 9·50 | 2⅛ | 2 1/16 |
| 9/16 | 5·65 | 8·40 | 7·90 | 11·80 | 2⅝ | 2 9/16 |
| ⅝ | 7·00 | 10·50 | 9·80 | 14·70 | 3¼ | 3 3/16 |
| 11/16 | 8·50 | 12·75 | 11·90 | 17·90 | 3⅝ | 3 9/16 |
| ¾ | 10·15 | 15·15 | 14·20 | 21·20 | 4⅜ | 4 5/16 |
| 13/16 | 11·90 | 17·80 | 16·60 | 24·90 | 5⅛ | 5 1/16 |
| ⅞ | 13·75 | 20·65 | 19·30 | 28·90 | 5⅞ | 5¾ |
| 15/16 | 15·80 | 23·70 | 22·10 | 33·20 | 6¾ | 6⅝ |
| 1 | 18·00 | 27·00 | 25·20 | 37·80 | 7⅝ | 7½ |
| 1 1/16 | 20·30 | 30·40 | 28·40 | 42·60 | 8⅝ | 8½ |
| 1⅛ | 22·75 | 34·15 | 31·90 | 47·80 | 9¾ | 9⅝ |
| 1 3/16 | 25·40 | 38·00 | 35·50 | 53·20 | 10⅞ | 10¾ |
| 1¼ | 28·15 | 42·15 | 39·40 | 59·00 | 12 | 11⅞ |
| 1 5/16 | 31·00 | 46·50 | 43·40 | 65·10 | 13¼ | 13 1/16 |
| 1⅜ | 34·00 | 51·00 | 47·60 | 71·40 | 14½ | 14 5/16 |
| 1 7/16 | 37·15 | 55·65 | 52·00 | 77·90 | 15⅞ | 15 11/16 |
| 1½ | 40·50 | 58·70 | 56·70 | 82·20 | 17¼ | 17 |
| 1 9/16 | 43·90 | 61·40 | 61·40 | 86·00 | 18¾ | 18½ |
| 1⅝ | 47·50 | 66·50 | 66·50 | 93·10 | 20 | 19⅝ |
| 1 11/16 | 51·25 | 71·75 | 71·75 | 100·50 | 21½ | 21⅛ |
| 1¾ | 55·15 | 77·15 | 77·15 | 108·00 | 23⅛ | 22¾ |
| 1 13/16 | 59·15 | 82·75 | 82·75 | 115·90 | 24⅞ | 24½ |
| 1⅞ | 63·25 | 88·50 | 88·50 | 123·90 | 26⅝ | 26⅛ |
| 1 15/16 | 67·50 | 94·50 | 94·50 | 132·30 | 28⅜ | 27⅞ |
| 2 | 72·00 | 100·80 | 100·80 | 141·10 | 30 | 29⅜ |
| 2 1/16 | 76·50 | 107·10 | 107·10 | 149·90 | 31⅞ | 31¼ |
| 2⅛ | 81·25 | 113·75 | 113·75 | 159·30 | 33¾ | 33 |
| 2 3/16 | 86·15 | 120·50 | 120·50 | 168·70 | 35⅞ | 35⅛ |
| 2¼ | 91·15 | 127·50 | 127·50 | 178·50 | 37⅞ | 37 |
| 2 5/16 | 96·25 | 134·75 | 134·75 | 188·75 | 40 | 39⅛ |
| 2⅜ | 101·50 | 142·10 | 142·10 | 198·90 | 42¼ | 41¼ |
| 2 7/16 | 106·90 | 149·65 | 149·65 | 209·50 | 44½ | 43⅜ |

(*See Continuation*)

TABLE 3B (INCH UNITS)—STUD LINK CHAIN CABLE (*Continued*)

(Subject to Anchors and Chain Cables Act)

| Diameter | GRADE | | | | Minimum weight per length of 15 fathoms | |
|---|---|---|---|---|---|---|
| | I and II | | III | | | |
| | Proof Load | Breaking Load | Proof Load | Breaking Load | With Dee Shackle | With Lugless Shackle |
| Inches | Tons | Tons | Tons | Tons | Cwts. | Cwts. |
| 2½ | 112·50 | 157·50 | 157·50 | 220·50 | 47 | 45⅞ |
| 2 9/16 | 116·70 | 163·40 | 163·40 | 228·70 | 49½ | 48¼ |
| 2⅝ | 120·90 | 169·25 | 169·25 | 237·00 | 52 | 50⅝ |
| 2 11/16 | 125·10 | 175·15 | 175·15 | 245·20 | 54½ | 53⅛ |
| 2¾ | 129·30 | 181·00 | 181·00 | 253·40 | 57⅛ | 55⅝ |
| 2 13/16 | 133·40 | 186·75 | 186·75 | 261·50 | 59⅞ | 58¼ |
| 2⅞ | 137·60 | 192·65 | 192·65 | 269·70 | 62⅝ | 60⅞ |
| 2 15/16 | 141·70 | 198·40 | 198·40 | 277·70 | 65½ | 63⅝ |
| 3 | 145·80 | 204·10 | 204·10 | 285·70 | 68⅜ | 66⅜ |
| 3 1/16 | 149·80 | 209·70 | 209·70 | 293·60 | 71¼ | 69⅛ |
| 3⅛ | 153·75 | 215·25 | 215·25 | 301·40 | 74¼ | 72 |
| 3 3/16 | 157·70 | 220·75 | 220·75 | 309·10 | 77⅜ | 75 |
| 3¼ | 161·60 | 226·20 | 226·20 | 316·70 | 80⅜ | 77⅞ |
| 3 5/16 | 165·40 | 231·50 | 231·50 | 324·10 | 83⅝ | 81 |
| 3⅜ | 169·15 | 236·75 | 236·75 | 331·50 | 86⅞ | 84⅛ |
| 3 7/16 | 172·75 | 241·80 | 241·80 | 338·50 | 90⅛ | 87⅛ |
| 3½ | 176·40 | 246·90 | 246·90 | 345·70 | 93½ | 90⅜ |
| 3 9/16 | 179·90 | 251·80 | 251·80 | 352·50 | 96¾ | 93½ |
| 3⅝ | 183·25 | 256·50 | 256·50 | 359·00 | 100 | 96½ |
| 3 11/16 | 186·50 | 261·10 | 261·10 | 365·50 | 103⅜ | 99¾ |
| 3¾ | 189·80 | 265·70 | 265·70 | 372·00 | 106⅝ | 102¾ |
| 3 13/16 | 192·90 | 270·00 | 270·00 | 378·00 | 109⅞ | 105⅞ |
| 3⅞ | 195·90 | 274·25 | 274·25 | 384·00 | 113¼ | 109 |
| 3 15/16 | 198·80 | 278·30 | 278·30 | 389·65 | 116¾ | 112¼ |
| 4 | 201·60 | 282·20 | 282·20 | 395·10 | 120⅝ | 116 |
| 4 1/16 | 204·20 | 285·90 | 285·90 | 400·25 | 124⅝ | 119¾ |
| 4⅛ | 206·70 | 289·40 | 289·40 | 405·15 | 128⅝ | 123½ |
| 4 3/16 | — | — | 292·60 | 409·65 | 132¾ | 127½ |
| 4¼ | — | — | 295·80 | 414·15 | 136⅞ | 131⅜ |
| 4 5/16 | — | — | 298·70 | 418·20 | 141⅛ | 135⅜ |
| 4⅜ | — | — | 301·40 | 422·00 | 145⅜ | 139⅜ |
| 4 7/16 | — | — | 303·80 | 425·35 | 149¾ | 143½ |
| 4½ | — | — | 306·15 | 428·60 | 154⅛ | 147⅝ |

TABLE 4—SHORT LINK CHAIN CABLE

| Diameter | GRADE | | | | Minimum weight per length of 27,5 metres | |
|---|---|---|---|---|---|---|
| | I and II | | III | | | |
| | Proof Load | Breaking Load | Proof Load | Breaking Load | Forged | Electric Welded |
| mm. | kg. | kg. | kg. | kg. | kg. | kg. |
| 11 | 2250 | 4500 | 3150 | 6300 | 100 | 60 |
| 12 | 2700 | 5400 | 3800 | 7600 | 115 | 75 |
| 13 | 3200 | 6400 | 4500 | 9000 | 130 | 95 |
| 14 | 3650 | 7300 | 5200 | 10400 | 145 | 115 |
| 15 | 4200 | 8400 | 5950 | 11900 | 160 | 135 |
| 16 | 4800 | 9600 | 6750 | 13500 | 175 | 155 |
| 17 | 5450 | 10900 | 7650 | 15300 | 195 | 175 |
| 18 | 6100 | 12200 | 8600 | 17200 | 215 | 195 |
| 19 | 6800 | 13600 | 9550 | 19100 | 240 | 215 |
| 20 | 7550 | 15100 | 10600 | 21200 | 265 | 235 |
| 21 | 8300 | 16600 | 11700 | 23400 | 290 | 260 |
| 22 | 9100 | 18200 | 12800 | 25600 | 315 | 285 |
| 23 | 9950 | 19900 | 14000 | 28000 | 345 | 310 |
| 24 | 10900 | 21700 | 15300 | 30500 | 375 | 340 |
| 25 | 11800 | 23600 | 16600 | 33100 | 405 | 370 |
| 26 | 12800 | 25500 | 17900 | 35800 | 440 | 400 |
| 27 | 13700 | 27400 | 19300 | 38500 | 475 | 435 |
| 28 | 14800 | 29500 | 20800 | 41500 | 510 | 470 |
| 29 | 15900 | 31700 | 22300 | 44500 | 545 | 505 |
| 30 | 17000 | 34000 | 23900 | 47700 | 580 | 540 |
| 31 | 18200 | 36300 | 25500 | 50900 | 620 | 575 |
| 32 | 19400 | 38700 | 27100 | 54200 | 655 | 615 |
| 33 | 20600 | 41100 | 28900 | 57700 | 695 | 650 |
| 34 | 21800 | 43600 | 30600 | 61200 | 740 | 690 |
| 35 | 23100 | 46200 | 32400 | 64800 | 785 | 730 |
| 36 | 24500 | 48900 | 34300 | 68600 | 830 | 770 |
| 37 | 25900 | 51700 | 36300 | 72500 | 875 | 810 |
| 38 | 27300 | 54600 | 38200 | 79400 | 920 | 855 |
| 39 | 28800 | 57500 | 40300 | 80500 | 970 | 905 |
| 40 | 30200 | 60400 | 42300 | 84600 | 1020 | 955 |
| 41 | 31700 | 63400 | 44500 | 89000 | 1070 | 1005 |
| 42 | 33300 | 66600 | 46700 | 93400 | 1125 | 1055 |
| 43 | 34900 | 69800 | 49000 | 97900 | 1180 | 1105 |
| 44 | 36600 | 73200 | 51300 | 102000 | 1240 | 1155 |
| 45 | 38300 | 76500 | 53600 | 107000 | 1300 | 1205 |
| 46 | 39900 | 79900 | 56000 | 112000 | 1360 | 1260 |
| 47 | 41700 | 83400 | 58200 | 117000 | 1425 | 1315 |
| 48 | 43500 | 87000 | 61000 | 122000 | 1490 | 1370 |
| 49 | 45400 | 90700 | 63500 | 127000 | 1555 | 1430 |
| 50 | 47300 | 94500 | 66200 | 132000 | 1625 | 1490 |
| 51 | 49200 | 98300 | 68800 | 138000 | 1695 | 1555 |

impact or bend tests taken. The test samples are to be subjected to the same heat treatment as the shackles.

**1314** ATTACHMENT LINKS, ADAPTOR PIECES, ETC., are to be subjected to the breaking and proof loads appropriate to the grade of cable for which they are intended. The breaking load is to be applied to 1 item out of every 25 (or less) and this item is to be destroyed and not used as part of an outfit. Where, however, the items are of increased dimensions, and have been specially approved, the breaking load may be applied to each item and the item so tested included with the outfit.

**1315** SWIVELS are to be tested as required by 1314 but the breaking load is to be applied to 1 out of every 7 (or less) unless made of increased dimensions.

**1316** All items subjected to the breaking load are to be destroyed and not used in the outfit except as specifically permitted by 1314 for items of increased dimensions.

## Section 14

## STEEL WIRE ROPES FOR STANDING RIGGING, TOWLINES AND MOORING ROPES; FIBRE ROPES

### STEEL WIRE ROPES

*Note.—For list of manufacturers of steel wire ropes see Appendix to this Chapter.*

#### Approval of Works

**1401** The manufacturer's plant and method of production are to be approved by the Committee. The works are to be at all times open to inspection of the Surveyor and periodical inspections are to be held at intervals not exceeding two years.

Each manufacturer is required to provide on his premises machines suitable for satisfactorily making the prescribed tests. The tensile testing machine is to be of an approved type and is to be calibrated at intervals not exceeding two years. Alternatively, tests carried out by a competent government, municipal or similar responsible body will be accepted.

#### Material

**1402** The wire used in the manufacture of the rope is to be drawn from steel billets made by the open hearth or other approved process and is to be of homogeneous quality, free from visual defects and of smooth uniform finish. The tensile strength of the wire should generally be within the range 130–160 kg. per mm.$^2$

#### Galvanising

**1403** The wire is to be galvanised to the Surveyor's satisfaction and is to be tested in accordance with 1410.

The weight of coating is not to be less than that given in the following table:—

| Diameter of uncoated wire | | Weight of coating |
|---|---|---|
| Mm. | | |
| Exceeding | Not exceeding | Grammes/m.$^2$ |
| 0,45 | 0,50 | 75 |
| 0,50 | 0,60 | 90 |
| 0,60 | 0,80 | 110 |
| 0,80 | 1,00 | 130 |
| 1,00 | 1,20 | 150 |
| 1,20 | 1,50 | 165 |
| 1,50 | 1,90 | 180 |
| 1,90 | 2,50 | 205 |
| 2,50 | 3,20 | 230 |
| 3,20 | 4,00 | 250 |

#### Construction of Ropes

**1404** The construction of wire ropes for standing rigging, towlines and mooring ropes is generally to be as given in the following table but alternative types of wire rope will be specially considered on the basis of an equivalent breaking load and the suitability of the construction for the purpose intended.

| Purpose | Construction of Rope | | | Construction of Strands |
|---|---|---|---|---|
| | Strands | Wires | Core | |
| Standing rigging | 6 | 7 | Fibre | 6 over 1 |
| | 7 | 7 | Wire | 6 over 1 |
| | 7 | 19 | Wire | 12 over 6 over 1 |
| | 7 | 37 | Wire | 18 over 12 over 6 over 1 |
| Mooring ropes and towlines | 6 | 12 | Fibre | 12 over fibre core |
| | 6 | 19 | Fibre | 12 over 6 over 1 |
| | 6 | 24 | Fibre | 15 over 9 over fibre core |
| | 6 | 37 | Fibre | 18 over 12 over 6 over 1 |

### Tests on Completed Rope

**1405** A sample of the completed rope shall be subjected to a breaking test to destruction. The sample shall be of sufficient length to provide a clear test length of at least 36 times the rope diameter. Not more than four-fifths of the nominal breaking load may be applied quickly and thereafter the load is to be applied slowly and steadily until the maximum load is obtained.

Tests in which a breakage occurs adjacent to the grips may, at the option of the manufacturer, be discarded.

The actual breaking load is not to be less than that given in the table below.

**1406** If facilities are not available for making a breaking test on completed ropes intended for standing rigging or mooring ropes, consideration will be given to the acceptance of the determination of the breaking load by the summation of the tests of individual wires and the deduction of a percentage for laying up. This percentage is not to be less than that given opposite. Manufacturers desiring to adopt this method of testing may be required to arrange for check breaking tests to be carried out on completed ropes.

| CONSTRUCTION OF ROPE | PERCENTAGE DEDUCTION |
|---|---|
| 6× 7 | 10 |
| 6×12 | 10 |
| 6×19 | 13 |
| 6×24 | 13 |
| 6×37 | 17½ |
| 7× 7 | 15 |
| 7×19 | 18 |
| 7×37 | 22½ |

**1407** For tests on the wires a suitable length shall be cut off the rope, unstranded and straightened. Six wires are to be subjected to either a torsion test or a wrapping test.

**1408** For the torsion test the length of sample shall be such as to allow a distance between the grips of 100 times the diameter of wire, but this distance need not exceed 300 mm. The wire is to be twisted by causing one or both of the vices to be revolved at a speed of between 60 and 70 turns per minute until fracture occurs. (A tensile load not exceeding 2 per cent of the breaking load of the wire may be applied to keep the wire stretched.) The wire shall withstand, on a length of 100 times the diameter of wire, 21 complete twists if finer than 3,0 mm. diameter, 19 complete twists if 3,0 mm. but finer than 3,2 mm. diameter or 17 complete twists if 3,2 mm. diameter or thicker.

| SIZE OF ROPE | | CONSTRUCTION AND BREAKING LOAD | | | | | | |
|---|---|---|---|---|---|---|---|---|
| DIAMETER | APPROX. CIRCUMFERENCE | 6×7 | 6×12 | 6×19 | 6×24 | 6×37* | 7×7 | 7×19 |
| mm | mm | kg | kg | kg | kg | kg | kg | kg |
| 8 | 25 | 3150 | 1850 | 2850 | 2900 | 3250 | | |
| 9 | 28 | 3950 | 2650 | 4100 | 3550 | 4200 | | |
| 10 | 32 | 4800 | 3100 | 4800 | 4300 | 4800 | 5300 | |
| 11 | 35 | 5800 | 3600 | 5550 | 5100 | 5950 | 6400 | |
| 12 | 38 | 7400 | 4700 | 7250 | 6000 | 7200 | 8200 | |
| 14 | 44 | 9800 | 5950 | 9200 | 8000 | 10000 | 10900 | 10350 |
| 16 | 51 | 12600 | 8100 | 12500 | 11500 | 13400 | 14000 | 14100 |
| 18 | 57 | 15700 | 9750 | 15000 | 14300 | 17200 | 17500 | 16900 |
| 20 | 63 | 20200 | 12450 | 19200 | 17300 | 21450 | 22400 | 21600 |
| 22 | 69 | 24100 | 14450 | 22300 | 20500 | 26200 | 26800 | 25000 |
| 24 | 76 | 28400 | 17700 | 27300 | 24100 | 28800 | 31500 | 29500 |
| 26 | 82 | 33000 | 21300 | 32800 | 30000 | 34300 | 36700 | 36900 |
| 28 | 88 | 39300 | 23900 | 36800 | 34300 | 40200 | 43600 | 41400 |
| 32 | 101 | 50400 | 31000 | 47800 | 43700 | 53500 | 56000 | 53700 |
| 36 | 113 | 64700 | 39000 | 60000 | 57000 | 68800 | 71800 | 67600 |
| 40 | 126 | 78900 | 49900 | 76800 | 69000 | 81400 | | 86400 |
| 44 | 138 | | | 92300 | 82200 | 100100 | | 103800 |
| 48 | 151 | | | 110600 | 100200 | 120700 | | 122700 |
| 52 | 163 | | | 127600 | 115900 | 137100 | | 143500 |
| 56 | 176 | | | 147500 | 132700 | 160900 | | 165700 |
| 60 | 189 | | | | | | | 189400 |

*This rope is made of wire having a tensile strength between 160 and 179 kg/mm².

**1409** If facilities are not available for carrying out the torsion test a wrapping test may be carried out on the unstranded wire. Six wires or five per cent of the wires in the rope, whichever is the greater, shall be subjected to this test which shall consist of wrapping the wire tightly eight times round a mandrel equal to its own diameter. The wire shall not fracture when unwrapped seven turns.

**1410** The galvanising is to be tested by a dip test carried out in accordance with a recognised standard.

### Certificates

**1411** Printed forms of certificates, approved by the Committee, are to be signed by the manufacturers and will be supplied to them on application.

## FIBRE ROPES

### General

**1412** Fibre ropes intended as mooring ropes may be made of coir, hemp, manilla or sisal or may be composed of synthetic (man-made) fibres. They may be either 3-strand (hawser laid) 4-strand (shroud laid) or 9-strand (cable laid) but other constructions will be specially considered.

**1413** Each length of rope is to be manufactured from only one type and grade of natural or synthetic fibre. The fibre is to be long staple unadulterated and free from defects.

**1414** Synthetic fibre ropes are to be suitable for the purpose intended and should comply with a recognised standard.

**1415** Weighting and loading matter is not to be added and any added lubricant is to be kept to a minimum. Any rot-proofing or water repellancy treatment shall not be deleterious to the fibre nor shall it add to the weight or reduce the strength of the rope.

### Testing

**1416** The breaking load is to be determined by testing to destruction a sample cut from the completed rope.

**1417** The minimum length of sample to be used in determining the breaking load of a fibre rope is to be as given in the following table. The specimen is to be loaded to the initial load, given in the Table as a percentage of the specified breaking load, and checked for diameter and evenness of lay-up. The load is then to be increased evenly and continuously at the rate shown in the Table until the specimen breaks.

If the sample is held by grips and the break occurs within 150 mm. of the grips the test may be repeated but not more than two tests may be made on any one coil.

TESTING OF FIBRE ROPES

| Material | Test Length mm. | Initial Loading | Speed of Loading to Fracture |
|---|---|---|---|
| Natural Fibre | 1800 | 2% | (0,15 metre ± 0,05 metre) per min. |
| Synthetic Fibre | 900 | 1% | 0,10 metres per min. maximum. |

**1418** Where difficulty is experienced in testing a sample of a completed synthetic fibre rope the Society will consider alternative methods of testing.

### Breaking Load

**1419** The actual breaking load is not to be less than that given in the following table:—

| Diameter | 3-Strand (Hawser laid) | 4-Strand (Shroud laid) | 9-Strand (Cable laid) |
|---|---|---|---|
| | BREAKING LOAD | | |
| mm | kg | kg | kg |
| 20 | 2880 | 2680 | |
| 22 | 3410 | 3170 | |
| 24 | 4065 | 3770 | |
| 26 | 4700 | 4365 | |
| 28 | 5500 | 5120 | |
| 30 | 6200 | 5775 | |
| 32 | 7130 | 6620 | |
| 36 | 8850 | 8200 | |
| 40 | 10650 | 9900 | |
| 44 | 12600 | 11950 | |
| 48 | 14850 | 13800 | 9250 |
| 52 | 17300 | 16050 | 10600 |
| 56 | 19880 | 18500 | 12220 |
| 60 | 22550 | 20950 | 14080 |
| 64 | 26100 | 24300 | 15450 |
| 72 | 32200 | 29900 | 18900 |
| 80 | 39500 | 36700 | 23100 |

### Certificates

**1420** Printed certificates issued by the manufacturer or a competent government, municipal or similar responsible body will be accepted. The certificate should give the breaking load, test length and speed of testing.

Section 15

## APPROVAL OF ELECTRODES FOR MANUAL ARC WELDING IN HULL CONSTRUCTION

**1501** The manufacturer's plant and method of production of the electrodes are to be such as to ensure reasonable uniformity in manufacture.

**1502** Electrodes will be approved subject to compliance with the following tests. The test pieces are to be prepared in the presence of the Surveyor and all tests carried out under his supervision.

**1503** Electrodes will be divided into Grades 1, 2 and 3 dependent on the results of the Charpy tests. In addition, if Grade 2 or Grade 3 electrodes comply with the requirements of the hydrogen test as given in 1514, a suffix H will be added to the Grade mark.

Electrodes which have satisfied the requirements of Grade 2 will also be considered as complying with Grade 1 requirements and those which have satisfied the requirements of Grade 3 will be considered as complying with Grades 1 and 2 requirements.

**1504** Grade A hull structural steel may be used in the preparation of all test pieces, but at the option of the manufacturer Grades B, C or D steel may be used for Grade 2 electrode test pieces and Grade E steel for Grade 3 electrode test pieces.

**1505** The welding current used is to be within the range recommended by the manufacturer and, where an electrode is stated to be suitable for both A.C. and D.C., A.C. is to be used for the preparation of the test assemblies.

### Deposited Metal Tests

**1506** Tensile and impact tests are to be made, under controlled conditions, on metal deposited from the electrodes.

Two all-weld-metal test assemblies are to be prepared in the downhand position as shown in Fig. 1, one using 4 mm. electrodes and the other using 8 mm. diameter electrodes or the largest size manufactured if this is less than 8 mm. diameter.

The weld metal is to be deposited in single or multi-run layers according to normal practice, and the direction of deposition of each layer is to alternate from each end of the plate, each run of weld metal being not less than 2 mm. and not more than 4 mm. thick. Between each run the assembly is to be left in still air until it has cooled to 250° C., the temperature being taken in the centre of the weld, on the surface of the seam.

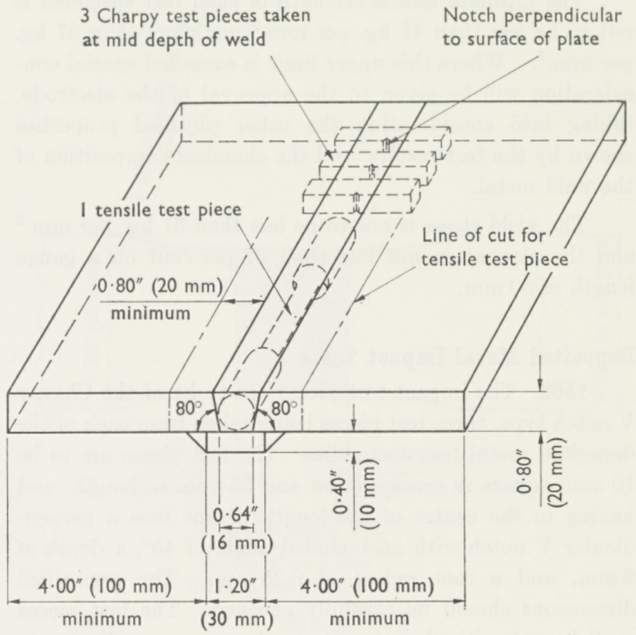



FIG. 1

After being welded the test assemblies are not to be subjected to any heat treatment.

### Deposited Metal Tensile Tests

**1507** The tensile test pieces, one from each all-weld-metal assembly, are to be machined to the dimensions shown in Fig. 2, care being taken that the longitudinal axis coincides with the centre of the weld, and the mid-thickness of the plates.

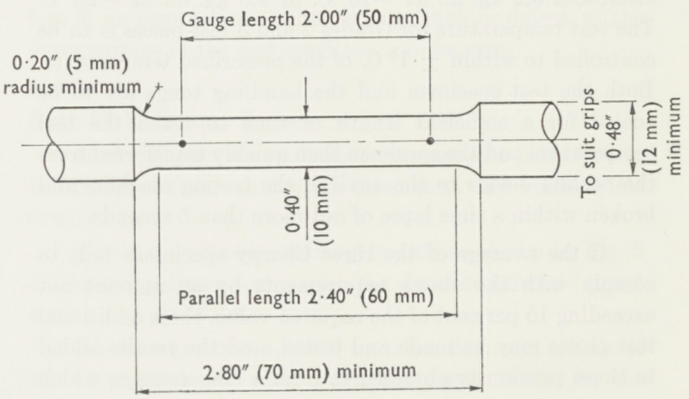



FIG. 2

The tensile test piece may be subjected to a temperature not exceeding 250° C. for a period not exceeding 16 hours for hydrogen removal, prior to testing.

The ultimate tensile strength of each test specimen is not to be less than 41 kg. per mm.$^2$ nor more than 57 kg. per mm.$^2$. Where this upper limit is exceeded special consideration will be given to the approval of the electrode, taking into consideration the other physical properties shown by the test results, and the chemical composition of the weld metal.

The yield stress is not to be less than 31 kg. per mm.$^2$ and the elongation not less than 22 per cent on a gauge length of 50 mm.

### Deposited Metal Impact Tests

**1508** The impact test pieces are to be of the Charpy V notch type, three test pieces being taken from each of the deposited metal test assemblies. The test pieces are to be 10 mm. square in cross section and 55 mm. in length, and having in the centre of the length of one face a perpendicular V notch with an included angle of 45°, a depth of 2 mm. and a root radius of 0,25 mm. The prescribed dimensions should be carefully checked. The test pieces shall be cut with their longitudinal axes perpendicular to the weld and the upper surface 5 mm. from the upper surface of the plate.

The notch shall be positioned in the centre of the weld and is to be cut in the face of the test piece perpendicular to the surface of the plate. The tests are to be carried out on an approved Charpy impact machine.

For Grade 1 electrodes the average impact value for the three specimens from each assembly shall not be less than 4,8 kg.m. at about 20° C. The corresponding value for Grade 2 electrodes is 4,8 kg. m. at 0° C. and for Grade 3 electrodes 6,2 kg. m. at —10° C. or 4,8 kg. m. at —20° C. The test temperature for Grades 2 and 3 test pieces is to be controlled to within ± 1° C. of the prescribed temperature. Both the test specimen and the handling tongs are to be cooled for a sufficient length of time to reach the test temperature and the specimen then quickly transferred from the cooling device to the anvil of the testing machine and broken within a time lapse of not more than 5 seconds.

If the average of the three Charpy specimens fails to comply with the above requirements by an amount not exceeding 15 per cent of the required value, three additional test pieces may be made and tested, and the results added to those previously obtained to form a new average, which must comply with the requirements.

When the average value of the three Charpy specimens is more than 15 per cent below the required value, then six more Charpy test pieces are to be prepared and the average value of these new test pieces is to comply with the requirements.

### Butt Weld Tests

**1509** Butt weld assemblies as shown in Fig. 3 are to be prepared for each welding position (downhand, vertical and overhead) for which the electrode is recommended by the manufacturer.

The test assemblies are to be made by welding together two plates 15 to 20 mm. in thickness not less than 100 mm.

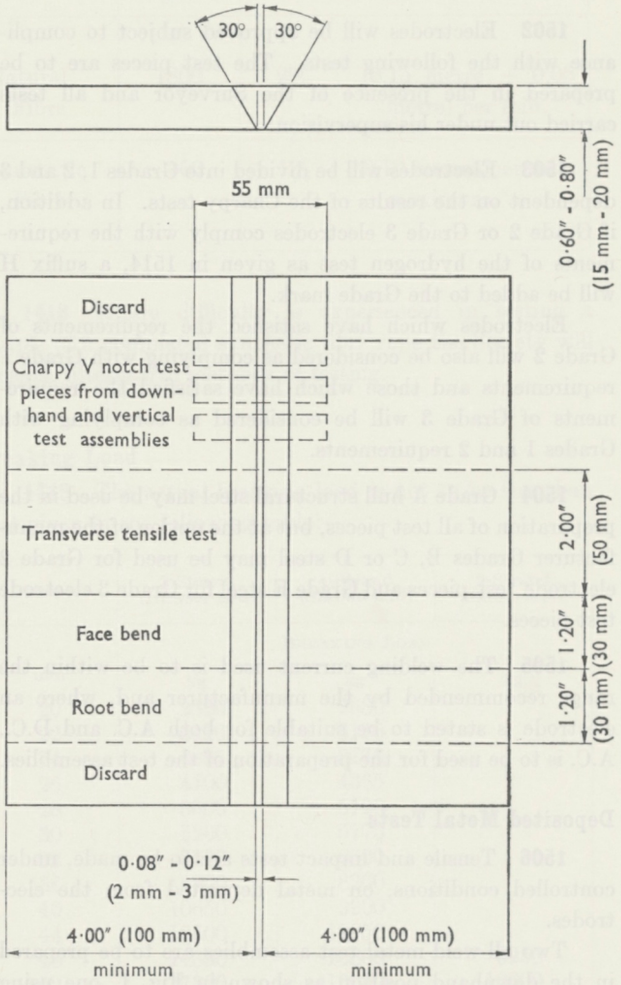



FIG. 3

in width and of sufficient length to allow the cutting out of test specimens of the prescribed number and size. The plate edges are to be prepared to form a single vee joint, the included angle between the fusion faces being 60° and the root gap being 2 to 3 mm.

Where the electrode is only to be approved in the downhand position an additional test assembly is to be prepared in that position.

The following welding procedure should be adopted in making the test assemblies:—

Downhand (a). First run with 4 mm. electrode. Remaining runs (except last two layers) with 5 mm. electrodes or above according to the normal welding practice with the electrodes. The runs of the last two layers with the largest size of electrode manufactured or 8 mm. whichever is the less.

Where a second downhand test is required:—

Downhand (b). First run with 4 mm. electrode. Next run with an intermediate size electrode 5 mm. or 6 mm. and the remaining runs with the largest size of electrode manufactured or 8 mm. whichever is the less.

Vertical and overhead. First run with 3,15 mm. electrode. Remaining runs with 4 mm. electrodes or possibly with 5 mm. electrodes if this is recommended by the manufacturer for the positions concerned.

In all cases the back sealing runs are to be made with 4 mm. electrodes in the welding position appropriate to each test sample, after cutting out the root run to clean metal. For electrodes suitable for downhand welding only, the test assemblies may be turned over to carry out the back sealing run.

The butts are to be welded using normal welding practice and between each run the assembly is to be left in still air until it has cooled to 250° C. the temperature being taken in the centre of the weld, on the surface of the seam.

After being welded the test assemblies are not to be subjected to any heat treatment.

It is recommended that the welded assemblies be subjected to a radiographic examination to ascertain any defects in the weld prior to testing.

Each assembly shall then be cut to form one tensile, one face bend, and one root bend as shown in Fig. 3, together with three Charpy specimens required from the downhand and vertical assemblies.

### Butt Weld Tensile Tests

**1510** Specimens of the form as shown in Fig. 4 are to be prepared.

The upper and lower surfaces of the weld are to be filed, ground or machined flush with the surface of the plate.

The ultimate tensile strength of each test piece shall not be less than 41 kg. per sq. mm.

### Butt Weld Bend Tests

**1511** The specimens are to be 30 mm. in width. The upper and lower surfaces of the weld are to be filed, ground or machined flush with the surface of the plate and the sharp

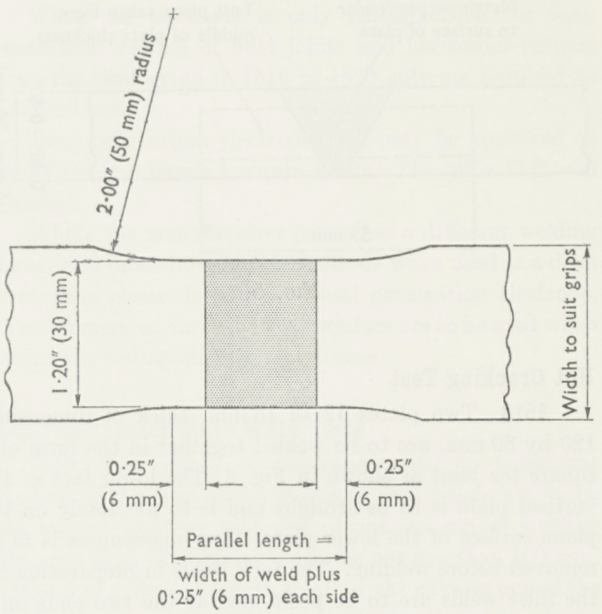



FIG. 4

corners of the specimens rounded to a radius not exceeding 2 mm.

The test specimens are to be capable of withstanding, without fracture, being bent through an angle of 120° over a former having a diameter three times the thickness of the specimen.

One specimen from each welded assembly is to be tested with the face of the weld in tension and the other with the root of the weld in tension.

The test pieces can be considered as complying with the test if, on completion of the test, no crack or defect, at the outer surface of the test specimen, can be seen.

### Butt Weld Impact Tests

**1512** Three Charpy V notch impact test pieces are to be machined from each of the downhand and vertical test assemblies.

The test pieces are to be prepared as shown in Fig. 5 of the same dimensions as for the deposited metal impact tests.

The test specimens are to be taken from the middle of the plate thickness with the notch perpendicular to the surface of the plate as shown in Fig. 5.

The average value of the results of the Charpy impact test pieces from the downhand assembly are to be in accordance with the requirements for deposited metal as given in 1508. The results from the vertical assembly are to be reported.

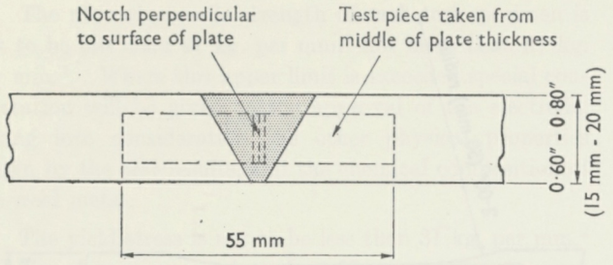



FIG. 5

### Hot Cracking Test

**1513** Two plates 12 to 15 mm. thick of dimensions 120 by 80 mm. are to be welded together in the form of a square tee joint as shown in Fig. 6 The lower face of the vertical plate is to be straight and, is to fit closely on the plane surface of the lower plate. Any unevenness is to be removed before welding. The tack welds in preparation for the fillet welds are to be positioned at the two ends on a level with the contact surface of the plates. The lower plate is to be stiffened by three transverse stiffeners in order to prevent distortion.

The fillet welding, which is to be made in one pass, is to be carried out in the downhand position and the welding current used is to be the maximum of the range recommended by the manufacturer for the size of electrode used.

The second fillet weld shall be started immediately after the completion of the first fillet weld and at the end of the specimen at which the first fillet weld finished. Both fillet welds are to be executed at a constant speed and without weaving.

For welding the full length of each fillet (120 mm.) the following lengths of electrodes are to be fused:—

| Diameter of electrode | Length of Fused Electrode | |
|---|---|---|
| | 1st fillet | 2nd fillet |
| 4 mm. | 200 mm. | 150 mm. |
| 5 mm. | 150 mm. | 100 mm. |
| 6 mm. | 100 mm. | 75 mm. |

After welding, the slag is to be removed from the fillet welds and after complete cooling they are to be examined for cracks by a magnifying glass or by the use of penetrant fluids.

The first fillet weld is then to be cut out by machining or gouging and the second weld broken by closing the two plates together, subjecting the root of the weld to tension. The weld shall then be examined for evidence of hot cracking. There should be no cracking in the fillet welds (except crater cracks) either superficial or internal.

### Hydrogen Test

**1514** Electrodes which have satisfied the requirements of Grade 2 or Grade 3 may, at the option of the manufacturer, be submitted to a hydrogen test, and a suffix H will be added to the Grade number to indicate compliance with the test requirements.

Four test specimens are to be prepared measuring 12 by 25 mm. in cross section by about 125 mm. in length. The parent metal may be any grade of shipbuilding steel

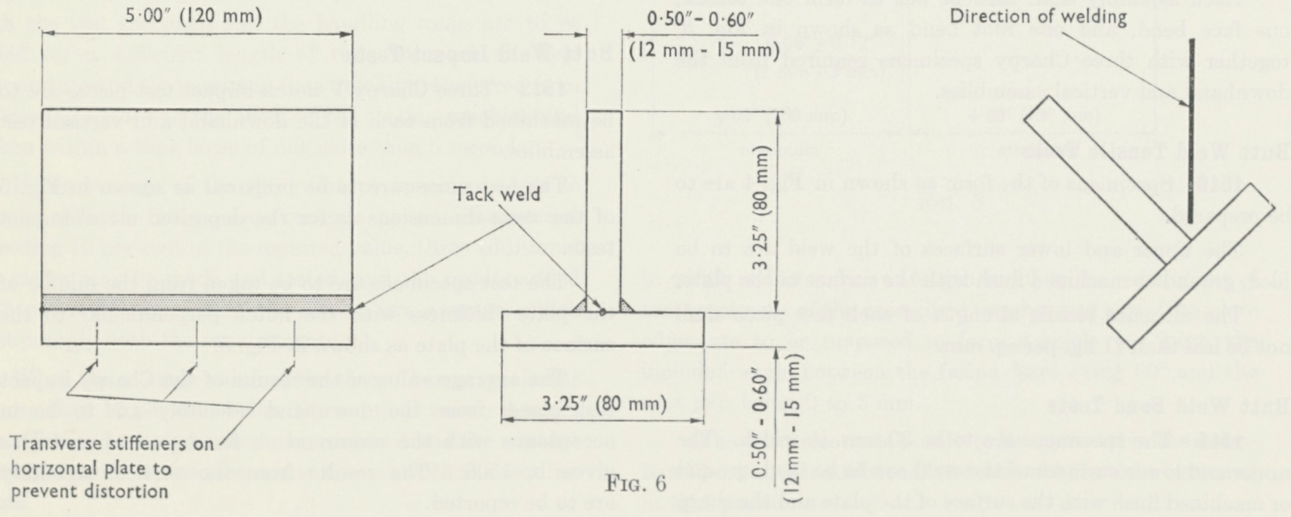



FIG. 6

and, before welding, the specimens are to be weighed to the nearest 0,1 gm. On the 25 mm. surface of each test specimen a single band of welding is to be deposited about 100 mm. in length by a 4 mm. electrode, using about 150 mm. of the electrode. The welding is to be carried out with as short an arc as possible and with a current of about 150 amp.

The electrodes, prior to welding, can be submitted to the normal drying process recommended by the manufacturer.

Within thirty seconds of the completion of the welding of each specimen the slag is to be removed and the specimen quenched in water at approximately 20° C. After a further 30 seconds the specimens are to be cleaned and placed in an apparatus suitable for the collection of hydrogen by displacement of glycerine. The glycerine is to be kept at a temperature of 45° C. during the test. All four specimens are to be welded and placed in the hydrogen collecting apparatus within 30 minutes.

The specimens are to be kept immersed in the glycerine for a period of 48 hours and, after removal, are to be cleaned in water and spirit, dried and weighed to the nearest 0,1 gm. to determine the amount of weld deposited.

The amount of gas evolved is to be measured to the nearest 0,05 c.c. and corrected for temperature and pressure to 20° C. and 760 mm. Hg.

The amount of hydrogen in terms of cubic centimetres per gram of weld metal is to be reported and is not to exceed an average of 0,1 c.c. per gram for the four specimens tested.

Alternatively, the hydrogen content of the weld metal may be determined by any mercury gas burette type of apparatus, in accordance with a recognised procedure. Proposals for alternative methods of carrying out the test are to be submitted for approval.

### Deep Penetration Electrodes

**1515** Where, in addition to its use as a normal penetration electrode, a manufacturer desires to demonstrate that an electrode also has deep penetrating properties when used for downhand butt welding and horizontal-vertical fillet welding, the additional tests given in 1516 to 1520 are to be carried out.

Where a manufacturer recommends that an electrode having deep penetrating properties can also be used for downhand butt welding of thicker plates with prepared edges, the electrode will be treated as a normal penetration electrode and the full series of tests in the downhand position are to be carried out, together with the deep penetration tests given in 1516 to 1520.

Where an electrode is only recommended for deep penetration welding of butt joints and horizontal-vertical fillets, the tests given in 1516 to 1520 only are required to be carried out.

Deep penetration electrodes will only be approved as complying with Grade 1 requirements. The suffix D.P. will be added.

Where the manufacturer prescribes a different welding current and procedure for the electrode when used as a deep penetration electrode and a normal penetration electrode, the recommended current and procedure are to be used when making the test specimens in each case.

### Deep Penetration Butt Weld Tests

**1516** Two plates of thickness equal to twice the diameter of the core of the electrode plus 2 mm. are to be butt welded together with one downhand run of welding from each side. The plates are to be not less than 100 mm. wide and of sufficient length to allow the cutting out of the test specimens of the correct number and size as shown in Fig. 7.

The joint edges are to be prepared square and smooth and, after tacking, the gap is not to exceed 0,25 mm.

The test assembly is to be welded using an 8 mm. diameter electrode or the largest size manufactured if this is less than 8 mm.

After welding, the test assembly shall be cut to form two transverse tensile test pieces, two bend test pieces and three Charpy V-notch impact test pieces.

The discards at the end of the welded assemblies are to be not more than 35 mm. wide. The joints of these discards are to be polished and etched and must show complete fusion and interpenetration of the welds. At each cut in the test assembly the joints are also to be examined to ensure that complete fusion has taken place.

### Deep Penetration Transverse Butt Weld Tensile Test

**1517** Two transverse butt weld tensile test specimens are to be prepared to the dimensions given in Fig. 4.

The upper and lower surfaces of the weld are to be filed, ground or machined flush with the surface of the plate.

The ultimate tensile strength of the test piece shall not be less than 41 kg. per mm.$^2$.

### Deep Penetration Butt Weld Bend Tests

**1518** Two butt weld bend tests are to be prepared in accordance with the requirements of 1511 and are to be capable of withstanding, without fracture, being bent through an angle of 120° over a former having a diameter three times the thickness of the specimen.

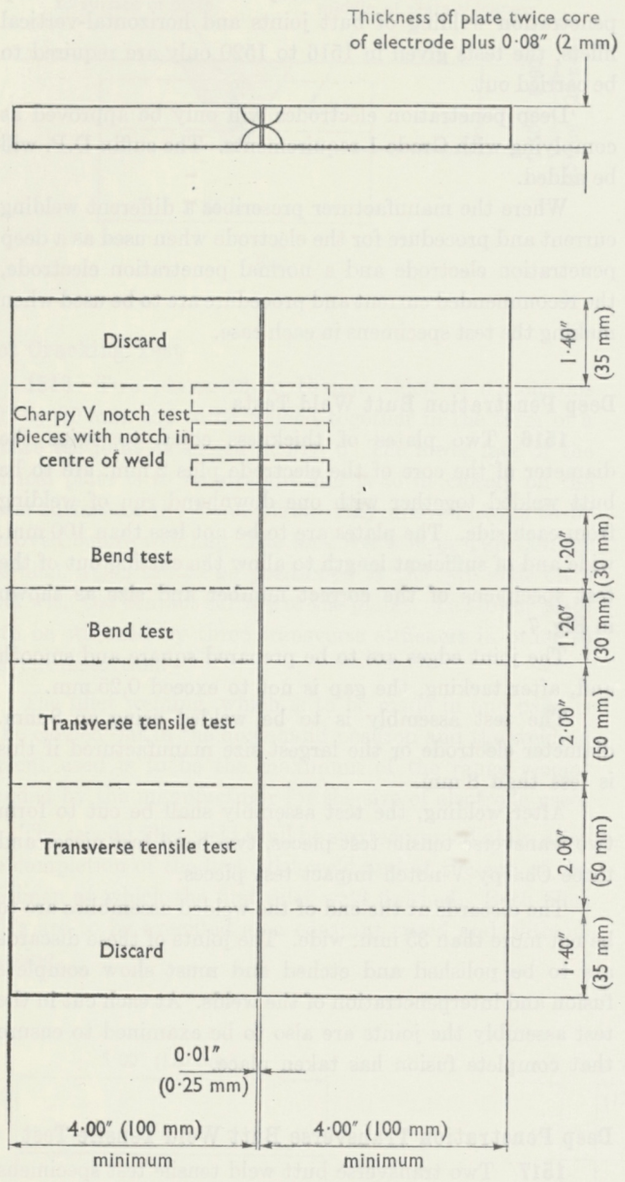



FIG. 7

One test piece shall be tested with the side first welded in tension and one with the other side in tension.

### Deep Penetration Butt Weld Impact Tests

**1519** Three Charpy V-notch impact test pieces are to be prepared, the notch being in the centre of the weld.

The dimensions of the test pieces are to be as given in 1508. The longitudinal axes of the test pieces are to be perpendicular to the direction of the weld, and they are to be taken from the centre of the plate thickness. The notch is to be cut in the face of the test piece perpendicular to the surface of the plate.

The average impact values for the three specimens taken from the centre of the weld shall not be less than 4,8 kg. m. at about 20° C.

### Deep Penetration Fillet Weld Test

**1520** A fillet weld assembly is to be prepared as shown in Fig. 8 with plates about 12,5 mm. in thickness.

The welding shall be carried out with one run for each fillet with plate A in the horizontal plane during the welding operations. The length of the fillet is to be 160 mm. and the gap between the plates is to be not more than 0,25 mm.

The fillet weld on one side of the assembly shall be carried out with a 4 mm. electrode and that on the other side with the maximum size of electrode manufactured. The welding current used is to be within the range recommended by the manufacturer and the welding is to be carried out using normal welding practice.

The welded assembly shall be cut by sawing or machining within 35 mm. of the ends of the fillet welds and the joints are to be polished and etched. The welding of the fillet made with a 4 mm. electrode is to show a penetration of 4 mm. (*see* Fig. 8) and the corresponding penetration of the fillet made with the maximum size of electrode manufactured is to be reported.

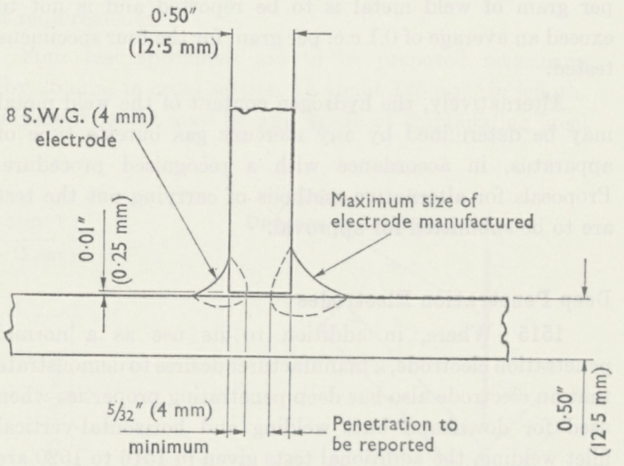



FIG. 8

### Chemical Analysis

**1521** The chemical analysis of the weld metal made by the electrode is to be supplied by the manufacturer.

**1522** The Committee is to be notified of any alteration proposed to be made in the process of manufacture subsequent to approval.

### Maker's Certificate

**1523** Each carton or package of approved electrodes is to contain a certificate from the manufacturer on the following lines:—

> "The ..... company certifies that the composition and quality of these electrodes conform with those of the electrodes used in making the test pieces submitted to and approved by the Committee of Lloyd's Register of Shipping".

### Periodical Inspection of Maker's Works and Annual Tests

**1524** All establishments where approved electrodes are manufactured shall be subject to annual inspection. On these occasions, samples of the approved electrodes shall be subjected to at least the following tests:—

One tensile and three impact specimens in duplicate are to be made from deposited metal as set forth in 1506, 1507 and 1508. One group of specimens is to be prepared using one size of electrode and one using another, neither size being smaller than 4 mm. nor larger than 8 mm.

The ultimate tensile stress, yield stress and elongation are to be in accordance with 1507 and the impact properties in accordance with 1508 for the approved Grade.

For electrodes approved for downhand deep penetration butts and horizontal vertical fillet welds the following tests are to be carried out:—

Two plates of thickness twice the core of the electrode plus 2 mm. are to be butt welded together with one downhand run of welding from each side using a 6 mm. electrode, or the largest size made if less than 6 mm. The plates are not less than 100 mm. wide and of sufficient length to cut out one transverse tensile specimen, two bend test specimens and three Charpy V-notch impact specimens to the dimensions shown in Fig. 7. The notch in the Charpy specimens is to be taken in the centre of the weld metal.

The dimensions of the test pieces and the requirements to be fulfilled are as set forth in the original approval tests in 1517, 1518 and 1519.

At each cut in the test assembly, the joints are to be examined to ensure that complete fusion has taken place.

For those electrodes which are approved for normal penetration welding and for deep penetration properties in the downhand position, these tests are to be carried out in addition to the deposited metal tests for normal penetration electrodes.

### Additional Tests

**1525** If any of the above tests fail, test pieces in duplicate of the same type are to be prepared (if possible using electrodes from the same batch) and are to be satisfactorily tested. (For special requirements for Charpy tests see 1508).

**1526** The Committee may require, in any particular case, such additional tests or requirements as may be necessary.

## Section 16

## ALUMINIUM ALLOY PLATES, BARS AND SECTIONS

*Note:—For list of manufacturers of Aluminium Alloys for shipbuilding purposes see Appendix to this Chapter.*

### General

**1601** Aluminium alloys used in the construction of ships classed, or proposed for classification, in the Society's Register Book are to be made at works recognised by the Committee and are to comply with the following requirements.

These requirements, however, are not intended to apply to sheets less than 4,5 mm. thick, or to angles less than $40 \times 40 \times 4{,}5$ mm. Where material of these scantlings is used, the physical properties and chemical composition may be in accordance with a recognised specification for an alloy suitable for marine use.

Alloys whose chemical composition differs from these requirements will be specially considered.

### Freedom from Defects

**1602** The finished material is to be free from cracks, surface flaws and lamination.

### Testing and Inspection

**1603** The prescribed tests and inspections are to be made at the place of manufacture prior to despatch; but, in the event of any material proving unsatisfactory in the course of being worked into ships due to faults in manufacture, such material shall be rejected, notwithstanding any previous certificate of satisfactory testing, and such further tests of the material from the same cast may be made as the Surveyor may consider desirable.

Where a continuous melting process is employed for the production of ingots, a cast is to be defined as the amount of metal tapped from the furnace without any further addition having been made.

**1604** All test pieces are to be selected by the Surveyor and tested in his presence, and he is to satisfy himself that the prescribed conditions are fulfilled.

**1605** The manufacturer is to supply to the Surveyor at the time of test a certificate of the chemical composition of the material submitted for approval and, at the discretion of the Surveyor, samples may be selected from the material for the purpose of check analyses.

### Additional Tests before Rejection

**1606** Where any of the test pieces first selected by the Surveyor do not fulfil the test requirements, then:—

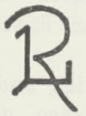
In the case of non-heat-treatable alloys, two further tests of the same kind may be made from the same plate, or section, but where either of these fail, the plate or section from which the test pieces were cut is to be rejected. In all such cases further tests are to be taken before any material from the same cast can be accepted.

In the case of heat-treatable alloys, the procedure laid down above is to be adopted, but the manufacturer may, should he so desire, re-heat-treat the whole of the material represented by the test piece before the two further test pieces are selected.

**1607** Where a tensile test piece breaks outside the middle half of its gauge length, and the elongation is less than that required by the Rules, the test may, at the manufacturer's option, be discarded and another test made of the same plate or section.

### Branding

**1608** Every plate or section is to be clearly and distinctly marked by the manufacturer in two places with the Society's brand, thus:— indicating that the material has complied with the Society's requirements.



**1609** Material bearing this brand is not to be forwarded from the works until the prescribed tests have been made by the Surveyor and the mill sheets have been signed by him. All material is also to be stamped in two places with the manufacturer's name or trade mark and the place where made. Material is also to be stamped with numbers, or identification marks, by which it can be traced to the cast from which it was made.

### Defacing of Rejected Material

**1610** In the event of the material failing to withstand the prescribed tests, the Surveyor is to see that the Society's brand, stamped on the material by the manufacturer, has been defaced by punch marks extending beyond the brand in the form of a cross, thus:— denoting that the material has been rejected.

### Manufacturer's Certificate

**1611** The mill sheets, presented to the Surveyor for signing, shall bear the following certificate printed on each sheet, with the name of the firm and initialled by the test house manager:—

"We hereby certify that the material described below satisfies the prescribed chemical composition and is that which has been satisfactorily tested in the presence of the Surveyor in accordance with the Rules of Lloyd's Register."

### Facilities for Inspection

**1612** The manufacturer is to adopt a system of marking which will enable all material presented for inspection to be traced to the original cast, and, in the case of heat-treatable material, to the particular batch in which it was heat-treated; a batch comprises all material simultaneously heat-treated in one furnace load. The Surveyor must be given every facility for tracing all material to its respective casts and for witnessing the required tests. When the Surveyor is satisfied with the material and with the results of tests, he is to be furnished with two copies of the advice notes for his signature, one of which is to be forwarded by the manufacturer to the shipbuilder, and the other is to be forwarded by the Surveyor to the Surveyors at the port where the ship is to be built.

### Aluminium Alloys not made where Wrought

**1613** Where the alloy is not made at the works where it is wrought, a certificate is to be supplied to the Surveyor stating the name of the maker of the material, also the numbers of the casts for reference to the books of the maker. The number of the cast is to be marked on each ingot or slab for the purpose of identification and the wrought material is also to be legibly stamped in two places with the manufacturer's name or trade mark and the place where finally wrought. The material is also to be stamped with numbers or identification marks by which it can be traced to the cast from which it was made.

### Additional Tests

**1614** In addition to the tests described hereafter, the material may be subjected to additional tensile tests at the discretion of the Surveyors.

**Aluminium Alloys of other Chemical Composition or Mechanical Properties**

**1615** When desired by owners and builders, consideration will be given by the Committee to proposals for the use of alloys differing in chemical composition or mechanical properties from those provided for in the Rules.

**Tensile Test Pieces**

**1616** The proof stress, the tensile strength and the ductility are to be determined from standard test pieces. The test for proof stress shall be carried out on each selected test piece either from a stress strain curve, by drawing a line parallel to the straight portion of the curve and distant from it by an amount representing the required maximum permanent elongation, thus determining the stress at which line and curve intersect; or by subjecting the test piece to the specified minimum proof stress and removing the load, when the test piece shall not have acquired a permanent elongation, measured by an extensometer, greater than that required by the Rules.

**1617** For material more than 22 mm. in thickness the width of the test piece between the gauge points is not to exceed 38 mm.; for material 22 mm. to 9,5 mm. in thickness, inclusive, the width is not to exceed 51 mm.; for material less than 9,5 mm. in thickness the width is not to exceed 63 mm. In other respects the test pieces are to conform to standard test piece A. (*See* P 312.)

Alternatively, a test piece having a gauge length of 51 mm., a width of 12,5 mm., a minimum parallel length of 63 mm. and a minimum radius at shoulder of 25 mm. may be used.

Wherever practicable, the wrought surfaces are to be retained on two opposite sides of the test piece.

**Straightening of Test Pieces**

**1618** Any straightening of test pieces which may be required is to be done cold, and the test pieces shall not receive further heat treatment or mechanical working before being tested except by machining to shape.

**Chemical Composition**

**1619** Plates, bars and sections where of non-heat-treatable aluminium alloy are to have the following chemical composition:—

| | | | | | | |
|---|---|---|---|---|---|---|
| Copper | ... | not more than | | 0,10 | per cent. | |
| Magnesium | ... | ,, | ,, | ,, | 5,50 | ,, ,, |
| ,, | ... | ,, | less | ,, | 3,50 | ,, ,, |
| Iron ... | .. | ,, | more | ,, | 0,75 | ,, ,, |
| Silicon | ... | ,, | ,, | ,, | 0,60 | ,, ,, |
| Manganese | ... | ,, | ,, | ,, | 1,00 | ,, ,, |
| Chromium | ... | ,, | ,, | ,, | 0,50 | per cent. |
| Zinc ... | ... | ,, | ,, | ,, | 0,10 | ,, ,, |
| Aluminium | ... | The remainder. | | | | |

**1620** Plates, bars and sections of heat-treatable aluminium alloy are to have the following chemical composition:—

| | | | | | | |
|---|---|---|---|---|---|---|
| Copper | ... | not more than | | 0,10 | per cent. | |
| Magnesium | ... | ,, | ,, | ,, | 1,50 | ,, ,, |
| ,, | ... | ,, | less | ,, | 0,40 | ,, ,, |
| Iron ... | ... | ,, | more | ,, | 0,60 | ,, ,, |
| Silicon | ... | ,, | ,, | ,, | 1,30 | ,, ,, |
| ,, | ... | ,, | less | ,, | 0,40 | ,, ,, |
| Manganese | ... | ,, | more | ,, | 1,00 | ,, ,, |
| ,, | ... | ,, | less | ,, | 0,40 | ,, ,, |
| Chromium | ... | ,, | more | ,, | 0,50 | ,, ,, |
| Zinc ... | ... | ,, | ,, | ,, | 0,03 | ,, ,, |
| Aluminium | ... | The remainder. | | | | |

**Bars and Sections**

**1621** May be formed by extrusion, rolling, or by drawing.

**Number of Tensile Tests : Plates**

**1622** Plates from the same cast shall be grouped in thickness for testing as follows:—

25 mm. and over in thickness.
19 mm. and less than 25 mm.
12,5 mm. and less than 19 mm.
4,5 mm. and less than 12,5 mm.

One tensile test is to be taken from each group.

**Number of Tensile Tests : Bars and Sections**

**1623** Sections from the same cast of non-heat-treatable material shall be grouped in weight as follows:—

Less than 1,5 kg. per metre.
Between 1,5 kg. and 13,5 kg. per metre, inclusive.
More than 13,5 kg. per metre.

One tensile test is to be taken from each group.

**1624** For sections from the same cast of heat-treatable alloy, the groups will be the heat-treatment batches as defined in P 1612. One tensile test is to be taken from each group.

**Tensile Tests : Plates and Sections**

**1625** The 0,1 per cent proof stress is to be not less than 12,5 kg. per mm.$^2$ The tensile breaking strength is to be not less than 27 kg. per mm.$^2$, and the elongation, measured on a gauge length of 200 mm. is to be not less than 10 per cent.

Alternatively, if the elongation is measured on a gauge length of 51 mm. it is to be not less than 12 per cent.

### Occasional Attendance at Works

**1626** Where the Surveyor is not in constant attendance at the works, the manufacturer may, with the written authority of the Society, comply with all the prescribed requirements and furnish the Surveyor with a certificate to the effect that the Society's Rules for the testing of aluminium alloys for shipbuilding purposes have been complied with in the case of material submitted for approval. The Surveyor is then to examine the works history sheets for the material submitted and, if these are in order, to take check tensile tests from the materials. If the material in a single cast is of uniform thickness, two tensile test pieces are to be selected; if of different thicknesses two tensile test pieces are to be selected from the range of thicknesses presented. The test pieces are to be selected by the Surveyor from the plates or sections themselves, and not from shearings previously detached from them, and, when marked by the Surveyor for testing, they are to be followed, as far as is practicable, through the different stages of preparation until the tests are completed. If more than one cast is represented each cast is to be tested.

**1627** Where the tests are unsatisfactory, the whole of the material from the cast is to be rejected and the Surveyor is to see that the Society's brand is satisfactorily defaced.

## Section 17

### ALUMINIUM ALLOY RIVET BARS AND MANUFACTURED RIVETS

### Testing of Material

**1701** All material from which rivets are manufactured is to be tested.

**1702** Tensile tests are to be selected in accordance with P 1623 or P 1624.

**1703** The 0,1 per cent proof stress is to be not less than 9,5 kg. per mm.$^2$ The tensile breaking strength is to be not less than 22 kg. per mm.$^2$, and the elongation is to be not less than 15 per cent if measured on a gauge length of eight times the diameter of the test piece (test piece B) or alternatively, not less than 18 per cent if measured on a gauge length of four times the diameter of the test piece (test piece C).

### Dump Test

**1704** Test pieces of a length and diameter equal to the full diameter of the bars, preferably cut from the same bars as the tensile tests shall, when cold, withstand being compressed without cracking, until the diameter is increased to 1,6 times the original diameter.

### Chemical Composition

**1705** Rivet bars and manufactured rivets where of non-heat-treatable aluminium are to have the following chemical composition:—

| | | | | | |
|---|---|---|---|---|---|
| Copper | ... | not more than | 0,10 | per cent. | |
| Magnesium | ... | ,, less ,, | 3,00 | ,, | ,, |
| ,, | ... | ,, more ,, | 4,00 | ,, | ,, |
| Silicon | ... | ,, ,, ,, | 0,60 | ,, | ,, |
| Iron | ... | ,, ,, ,, | 0,70 | ,, | ,, |
| Manganese | ... | ,, ,, ,, | 1,00 | ,, | ,, |
| Chromium | ... | ,, ,, ,, | 0,50 | ,, | ,, |
| Aluminium | ... | The remainder. | | | |

**1706** Rivet bars and manufactured rivets where of heat-treatable material are to have the chemical composition as laid down in P 1620.

### Manufactured Rivets: Heat Treatment and Testing

**1707** Rivets of non-heat-treatable alloys are to be supplied in the annealed condition.

Rivets of heat-treatable alloy are to be delivered to the shipyard in the heat-treated condition specified. If, however, suitable facilities are available, then with the concurrence of the rivet manufacturer, the heat treatment may be carried out in the shipyard.

**1708** Rivets selected by the Surveyor from bulk are to withstand the tests described in 1709.

**1709** Test pieces, cut from the shanks of manufactured rivets, of a length and diameter equal to the full diameter of the shank, shall, when cold, withstand being compressed in an axial direction, without cracking, until the diameter is increased to 1,6 times the original diameter.

## Section 18

### WELDING OF ALUMINIUM ALLOYS

### General

**1801** For general requirements where welding is employed, *see* D 3130.

### Processes

**1802** The following welding processes are to be adopted in the welding of non-heat-treatable aluminium alloys:

Inert gas metal arc welding.
Inert gas tungsten arc welding.
Other processes are to be submitted for approval.

### Filler Wire

**1803** The chemical composition of filler wire used in welding is to conform to the following requirements:—

| | | | | | | |
|---|---|---|---|---|---|---|
| Copper | ... | not more than | | 0,10 | per cent. | |
| Magnesium | ... | ,, | ,, | 5,50 | ,, | ,, |
| ,, | ... | ,, | less ,, | 4,50 | ,, | ,, |
| Iron ... | ... | ,, | more ,, | 0,70 | ,, | ,, |
| Silicon | ... | ,, | ,, | 0,60 | ,, | ,, |
| Manganese | ... | ,, | ,, | 1,00 | ,, | ,, |
| Chromium | ... | ,, | ,, | 0,50 | ,, | ,, |
| Aluminium | ... | The remainder. | | | | |

## Section 19

## CAST IRON CRANK SHAFTS

### General

**1901** Cast iron crank shafts are to be cast at an approved foundry to an approved material specification, and to approved manufacturing and inspection procedures. The inspection procedure will include the approved size, form and location of the test blocks on the crank shaft castings.

### Grades of Cast Iron

**1902** Any suitable grade of flake graphite, low alloy, acicular or spheroidal or nodular graphite cast iron may be used for crank shafts. The minimum tensile strength of the particular grade of cast iron, corresponding to the section of the crank shaft, is not to be less than that detailed in the approved Specification. (*See* H 627 and H 628, also N 330 and N 331).

### Process of Manufacture

**1903** The raw materials of a charge such as pig iron, return scrap and scrap steel, are to be specially selected. The melt is to be closely controlled particularly with regard to temperature, time and composition when inoculated irons are being produced. Where such irons are made, the casting temperature and the time between completion of the inoculation and finished pouring of the castings are to be recorded. The records are to be available to the Surveyor at any time.

The Surveyor is to be provided with a statement giving the chemical composition of the material used for each crank shaft or batch of crank shafts.

### Heat Treatment

**1904** In general, crank shaft castings other than those which are fully annealed, normalised or oil quenched and tempered, are to receive a suitable stress relief heat treatment before machining.

**1905** All heat treatments of castings are to be carried out in properly constructed furnaces which are efficiently maintained and have adequate means of temperature control of the furnace charge. Each casting is to be slowly and uniformly heated to the necessary temperature.

**1906** Unless otherwise agreed, test blocks are not to be removed from castings until all heat treatments have been completed. Test blocks are to receive the same heat treatment as the castings and are to be removed from castings and cut to provide test pieces by methods which do not impair or modify the characteristics of the materials. Flame cutting is not permitted for the removal of test blocks from a casting or for cutting up test blocks to provide test pieces.

### Provision of Test Material

**1907** Unless otherwise approved, test material is to be provided by test blocks cast integral with or gated from each crank shaft. The test blocks are to be sufficient in number to allow of retests, if required. The dimensions of test blocks are to be such as to ensure that the material properties are similar to those of the average section of the crank shaft casting.

### Dimensions of Test Pieces

**1908** The diameter of a tensile test piece is to be as large as practicable. In general, it should not be less than 14 mm. diameter.

A small flat is to be ground on each crank shaft casting and the Brinell hardness determined.

### Number of Tests

**1909** At least one tensile test piece is to be taken fo each crank shaft.

### Testing Machines

**1910** Tensile tests are to be carried out by competent personnel in an approved machine of adequate capacity. The machine is to be maintained in an efficient and accurate condition and is to be checked and calibrated at suitable intervals agreed by the Society.

### Mechanical Properties

**1911** The results of the tensile and hardness tests are to comply with the approved specification for the material.

### Additional Tests Before Rejection

**1912** Where the results of a tensile test do not comply with the specification, two retests are permitted. If the results of both retests are satisfactory the casting is acceptable as regards the tensile test. If either of the retests fails the casting is unacceptable. For castings which were fully heat treated, reheat treatment followed by retesting may be permitted provided the size of the residue of the test block(s) is suitable, and the agreement of the Surveyor is obtained.

### Batch Testing

**1913** In the case of small shafts which are produced in quantity and are heat treated together, a system of batch testing may be adopted with the agreement of the Surveyor. In these cases, however, not less than two test pieces are required per melt of which one is to represent the first shaft to be cast and the other the last shaft to be cast.

### Inspection of Castings

**1914** Where surplus material is to be removed from crank shaft castings before despatch, a machining method is to be employed. Flame cutting is not permissible.

Finished castings which have passed test are to be examined by the Surveyor before despatch. The castings are to be in a clean condition so that all surfaces may be examined including those of bores. Castings are to be free from cracks and other detrimental defects. Cast iron crank shafts are not to be repaired by welding and blemishes are not to be plugged with a filler.

### Branding

**1915** Every casting, after it has withstood satisfactorily the prescribed tests and inspection, is to be clearly marked by the Surveyor indicating that the casting has complied with the requirements of the Society.

In the event of any casting proving unsound during machining or at any subsequent stage of survey, it is to be rejected notwithstanding any previous certificate of satisfactory test and inspection.

### Surface Treatment

**1916** Where it is proposed to harden the surfaces of machined pins and/or journals of cast iron crank shafts, details of the process are to be submitted for approval. Before such a process is applied to a crank shaft it is to be demonstrated by procedure tests and to the satisfaction of the Surveyor, that the process is suitably controlled and does not impair the strength or soundness of the material.

*21st May, 1964*

# APPENDIX

## STEEL MANUFACTURERS

The following establishments have complied with the requirements for quality and testing of steel and have been recognised by the Committee.

### Firms in Great Britain and Ireland

Allen, Edgar, & Co., Ltd., Imperial Steel Works, Tinsley, Sheffield 9. (*Castings.*)
Alston Foundry Co., Ltd., Nent Force Foundry, Alston, Cumberland. (*Small castings.*)
Andrews Toledo, Ltd., Toledo Steel Works, Neepsend, Sheffield. (*Ingots, billets and bars.*)
Appleby-Frodingham Steel Co., Branch of the United Steel Companies, Ltd., Scunthorpe, Lincs. (*Slabs, blooms, billets, plates, sections, bars and rods.*)
Armstrong Whitworth (Metal Industries) Ltd., Western Road Works, Jarrow. (*Castings and ingots for forging.*)
Atlas Steel Foundry and Engineering Co., Ltd., The, Armadale, West Lothian. (*Castings.*)

Babcock & Wilcox, Ltd., Renfrew. (*Small castings.*)
Baird, Archibald, & Sons, Ltd., Hamilton, Lanarkshire. (*Castings.*)
Bairds & Scottish Steel, Ltd., Coatbridge, Lanarkshire,
Northburn Works. (*Ingots, billets, sections and bars.*)
Waverley Works. (*Sections and bars.*)
Victoria Works. (*Sections and bars.*)
Coats Works. (*Sections and bars.*)
Rochsolloch Works. (*Sections and bars.*)
Baker, J., & Bessemer, Ltd., Kilnhurst Steel Works, near Rotherham. (*Ingots and forgings.*)
Baker, W. A., & Co., Ltd., Westgate Works, Newport, Mon. (*Castings.*)
Baker Perkins Ltd., Peterborough. (*Small castings.*)
Barrow Steel Works, Ltd., Barrow-in-Furness, Lancashire. (*Billets, bars and sections.*)
Beardmore, William, & Co., Ltd., Parkhead, Glasgow. (*Castings, ingots, forgings, billets and blooms.*)
Blackett, Hutton & Co., Ltd., Cleveland Steel Foundry, Guisborough, Yorkshire. (*Castings.*)
Blair, George, & Co., Ltd., Armond Carr Works, Tow Law, Co. Durham. (*Castings.*)
Bond's Foundry Co., Tow Law, Co. Durham. (*Small castings.*)
Bonnington Castings, Ltd., Leith. (*Small castings.*)
British Rolling Mills, Ltd., Brymill Works, Tipton, Staffs. (*Cold drawn bright bars.*)
Briton Ferry Steel Co., Ltd., Briton Ferry, Neath, Glamorgan. (*Billets.*)
Brockhouse Castings, Ltd., Wednesfield, Wolverhampton. (*Small castings.*)
Brown Bayley Steels, Ltd., Sheffield. (*Ingots, forgings and bars.*)
Brown, The David, Industries, Ltd., (Foundry Division), Penistone, Yorks. (*Castings.*)
Brown, Lenox & Co., Ltd., Pontypridd. (*Castings.*)
Brymbo Steel Works, Branch of G.K.N. Steel Co., Ltd., Brymbo, Wrexham, North Wales. (*Electric steel for forging and re-rolling.*)
Carntyne Steel Castings Co., Ltd., Moorpark, Renfrew. (*Castings.*)
Catton & Co., Ltd.,
Yorkshire Steel Foundry, 29, Chadwick Street, Hunslet, Leeds. (*Castings.*)
Pontefract Lane, Leeds. (*Small castings.*)
Clyde Alloy Steel Co., Ltd.,
Craigneuk Works, Flemington, Motherwell. (*Castings, forgings, billets and bars.*)
Hallside Works, Newton, Glasgow. (*Castings and billets.*)
Coghlan Forge & Rolling Mills, Ltd., and Coghlan Bright Steel, Ltd., Hunslet Forge, Leeds. (*Rolling mills for bars; forgings.*)

Colvilles Ltd.,
- Blochairn Works, Glasgow. (*Plates.*)
- Clydebridge Steel Works, Cambuslang, near Glasgow. (*Plates.*)
- Dalzell Steel and Iron Works, Motherwell, Lanarkshire. (*Plates, sections, bars and blooms.*)
- Glengarnock Steel Works, Glengarnock, Ayrshire. (*Sections and bars.*)
- Ravenscraig Works, Ravenscraig, Lanarkshire. (*Ingots, rolled slabs and thin plates.*)

Consett Iron Co., Ltd., Blackhill, Durham.

Consett Iron Co., Ltd., (Jarrow Mill), Blackett Street, Jarrow-on-Tyne. (*Rolling mills for sections and rounds.*)

Crofts (Engineers), Ltd., Thornbury, Bradford. (*Castings.*)

Cruikshank & Co., Ltd., Denny Iron Works, Denny, Stirlingshire. (*Small castings.*)

Darlington Forge Ltd., Albert Hill, Darlington. (*Castings, ingots and forgings.*)

Darlington & Simpson, Rolling Mills Ltd., Darlington. (*Rolling mills for small sections and bars.*)

Darwins Ltd., Tinsley, Sheffield. (*Ingots and forgings.*)

Davy & United Roll Foundry, Ltd., Empire Works, Haverton Hill, Billingham, Co. Durham. (*Castings.*)

Dorman, Long (Steel) Ltd.,
- Britannia Works, Middlesbrough. (*Rolling mills for sections and bars.*)
- Cleveland Works, South Bank, Middlesbrough. (*Sections and bars.*)
- Lackenby Works, Middlesbrough. (*Ingots, billets, sections, bars and strips.*)
- Redcar Works, Redcar. (*Plates.*)

Emerson Walker Limited, Teams, Gateshead, Co. Durham. (*Castings.*)

English Steel Casting Corporation, Ltd., Grimesthorpe Works, Sheffield. (*Ingots and castings.*)

English Steel Forge & Engineering Corporation Ltd.,<br>
English Steel Rolling Mills Corporation Ltd., }
- North St. Works, Openshaw, Manchester. (*Forgings, bars, plates up to $\frac{1}{2}$ inch in thickness.*)
- River Don Works, Sheffield. (*Forgings, plates, billets and bars.*)

Etna Iron and Steel Co., Ltd., Motherwell, Lanarkshire. (*Rolling mills for sections and bars.*)

Firth Brown, Ltd.,
- Atlas Works, Sheffield. (*Ingots, forgings, rolled bars and billets.*)
- Scunthorpe Works, Scunthorpe, Lincs. (*Castings.*)

Firth Vickers Stainless Steels, Ltd., Sheffield. (*Rolling mills for plates, bars and sections; also castings.*)

Fox, Samuel, & Co., Ltd., Stocksbridge Works, near Sheffield. (*Ingots.*)

Glanmorfa Ltd., Llanelly. (*Castings.*)

Guest, Keen & Nettlefolds (South Wales), Ltd., Cardiff.
- Castle Works. (*Rolling mills for bars and strips.*)
- Tremorfa Works. (*Rolling mills for bars and sections.*)

Guest Keen Iron & Steel Co., Ltd., East Moors, Cardiff. (*Ingots, blooms and billets; sections and bars.*)

Hadfields, Ltd., East Hecla Works, Sheffield. (*Ingots, blooms, billets, forgings, bars, special sections and castings.*)

Halesowen Steel Co., Ltd., The, Halesowen, near Birmingham. (*Cold drawn bright bars.*)

Hamilton, A., & Sons, Ltd., Victoria Foundry, East Moors, Cardiff. (*Small castings.*)

Head, Wrightson Steel Foundries, Ltd.,
- Light Pipe Hall Road, Stockton-on-Tees. (*Castings.*)
- Teesdale Iron Works, Thornaby-on-Tees. (*Castings.*)

Hopkinsons, Ltd., Britannia Works, Huddersfield, Yorkshire. (*Castings.*)

Hyde, Robert & Son, Ltd.,
- Clarendon Works, Chesterfield. (*Small castings.*)
- North Stafford Steel Works, Stoke-on-Trent. (*Small castings.*)

Jackson, Elphick & Co., Ltd., Larkhall, Lanarkshire. (*Castings.*)

Jessop-Saville, Ltd., Brightside Works, Sheffield. (*Ingots, blooms, bars, forgings and castings.*)

Jopling, E., & Sons, Pallion, Sunderland. (*Castings.*)

K. & L. Steelfounders & Engineers Limited, Letchworth, Hertfordshire. (*Castings.*)

Kirkstall Forge Engineering, Ltd., Leeds. (*Rolling mills for bars, forgings and heavy drop forgings.*)

Lake & Elliot, Ltd., Engineers and Founders, Braintree, Essex. (*Small castings.*)
Lanarkshire Steel Co., Ltd., Motherwell, Lanarkshire. (*Sections.*)
Lancashire Steel Manufacturing Co., Ltd.,
Irlam, Manchester. (*Billets, bars, sections and castings.*)
Pearson & Knowles Works, Warrington, Lancs. (*Rolling mills for sections and bars.*)
Lilleshall Co., Ltd., St. George's, near Oakengates, Shropshire. (*Rolling mills for sections and bars.*)
Llanelly Steel Co. Ltd., Llanelly Steel Works, Llanelly. (*Billets and bars.*)
Lloyd, F. H., & Co., Ltd.,
James Bridge, near Wednesbury, Staffordshire. (*Ingots and castings.*)
Cardiff Works, Curran Road, Cardiff. (*Ingots and castings.*)
Lloyds (Burton) Ltd., Wellington Works, Burton upon Trent, Derbyshire. (*Ingots and castings.*)
Lysaght's Scunthorpe Works, Branch of G.K.N. Steel Co., Ltd., Scunthorpe, Lincs. (*Ingots, billets, slabs and bars.*)
Martins (Dundyvan), Ltd., Coatbridge, Lanarkshire. (*Rolling mills for sections.*)
Mills, Exors. of James, Ltd., Bredbury Steel Works & Rolling Mills, near Stockport. (*Rolling mills for bars.*)
Monks, Hall & Co., Ltd., Warrington. (*Rolling mills for bars.*)
National Steel Foundry (1914), Ltd., The, Kirkland Works, Leven, Fifeshire. (*Castings.*)
North British Steel Foundry, Ltd., The, Balbardie Steel Works, Bathgate. (*Castings.*)
Osborn, Samuel, & Co., Ltd., Clyde Steel Works, Sheffield. (*Castings.*)
Park Gate Iron & Steel Co., Ltd., Rotherham, Yorkshire.
Parker Foundry (1929) Ltd., Mansfield Road, Derby. (*Small castings.*)
Patent Shaft Steel Works, Ltd., Wednesbury, Staffordshire.
Raine & Co., Ltd., Delta Iron & Steel Works, Derwenthaugh, Newcastle upon Tyne. (*Rolling mills for sections and bars.*)
Redheugh Iron & Steel Co. (1936), Ltd., Teams, Gateshead-on-Tyne. (*Rolling mills.*)
Renton & Fisher, Ltd., Hopetoun Steel Works, Bathgate. (*Castings.*)
Robertson, Wm., Ltd., Latchford, Warrington. (*Cold drawn bright bars.*)
Round Oak Steel Works, Ltd., Brierley Hill, Staffordshire. (*Ingots, blooms, billets, bars and sections.*)
Ryder Brothers, Ltd. (Beehive Steel Foundry), Bolton. (*Small castings.*)
Sanderson Brothers & Newbould Limited, Sheffield. (*Ingots, billets and bars.*)
Shaw, W., & Co., Ltd., Wellington Cast Steel Foundry, Middlesbrough. (*Castings.*)
Shelton Iron & Steel, Ltd., Stoke-on-Trent. (*Ingots, billets, bars and sections.*)
Skinningrove Iron Co., Ltd., Skinningrove Iron Works, Saltburn-by-the-Sea. (*Sections and bars.*)
South Durham Steel & Iron Co., Ltd.,
West Hartlepool. (*Plates.*)
Cargo Fleet Ironworks, Middlesbrough. (*Sections and bars.*)
Spartan Steel and Alloys Ltd., Spartan Works, Birmingham 6. (*Ingots.*)
Spear & Jackson, Ltd., Sheffield. (*Ingots and billets.*)
Springfield Steel Co., Ltd., 1323, London Road, Glasgow. (*Castings.*)
Steel Company of Wales, Ltd., Abbey Works, Port Talbot. (*Ingots, plates and strips.*)
Steel, Peech & Tozer, Rotherham, Branch of The United Steel Companies Ltd. (*Ingots, blooms, forgings, rivet and stay bars.*)
Stewarts & Lloyds, Ltd.,
Bilston Iron & Steel Works, Bilston, Staffordshire. (*Tube ingots, billets and bars.*)
Clydesdale Steel and Tube Works, Bellshill, Lanarkshire. (*Ingots, billets, slabs and strips for tubes.*)
Corby Works, Corby, Northants. (*Ingots, billets, slabs and strips.*)
Tollcross Foundry, Tollcross, Glasgow. (*Castings.*)
Summers, John, & Sons Ltd., Hawarden Bridge Steel Works, Shotton, Chester. (*Ingots, slabs and light plates.*)
Summersons Foundries, Ltd., Darlington. (*Small castings.*)
Taylor Bros. & Co., Ltd., Trafford Park Steel Works, Manchester. (*Ingots.*)

Thomas, Richard, & Baldwins Ltd.,
Ebbw Vale Works, Ebbw Vale, Monmouthshire. (*Ingots.*)
Redbourne Works, Scunthorpe. (*Ingots, billets, bars and slabs.*)
Spencer Works, Llanwern, near Newport, Monmouthshire. (*Light plates.*)
Vickers-Armstrongs (Engineers), Ltd.,
Barrow-in-Furness. (*Castings and forgings.*)
Elswick Works, Elswick, Northumberland. (*Castings.*)
Washington Steel Foundries, Ltd., Washington Station S.O., Co. Durham. (*Castings.*)
West Lothian Steel Foundry Co., Ltd., Harthill Works, Armadale, West Lothian. (*Small castings.*)
Whitehead Iron & Steel Co., Ltd., Courtybella Works, Newport, Mon. (*Rolling mills for strips, bars and sections.*)
Whitehead, Thomas, Bar and Strip Co., Ltd., Redbourne Works, Scunthorpe, Lincs. (*Rolling mills for bars and strips.*)
Williams, John, (Wishaw), Ltd., Excelsior Iron & Steel Works, Wishaw, Lanarkshire. (*Rolling mills for thin plates.*)
Wilson's Foundry & Engineering Co., Ltd., Bishop Auckland, Co. Durham. (*Castings.*)
Wolsingham Steel Co., Ltd., Wolsingham, Co. Durham. (*Castings and forgings.*)
Workington Iron & Steel Co., Workington, Cumberland. (*Ingots, blooms, billets, slabs and bars for manufacture of small forgings (Acid Bessemer or electric steel); rolled sections (electric steel only).*)

FIRMS IN COUNTRIES OTHER THAN GREAT BRITAIN AND IRELAND (ALPHABETICALLY ARRANGED)

Note : The place of residence of the Surveyor giving attendance at each works is shown in parentheses.

A.1. Iron & Steel Foundry, Ltd., Vancouver, B.C. (*Small castings.*) (VANCOUVER.)

A.S.S.A. Acciaierie di Susa Società Anonima, Turin, Italy. *Head Office:* Turin. *Works:* Susa. (*Castings.*) (GENOA.)

Acerias y Forjas de Azciotia, Azciotia Juipuzcoa, Spain, (*Ingots and small rolled bars.*) (BILBAO.)

Aceros de Galicia, Vigo, Spain. (*Castings.*) (GIJON.)

Aceros del Zarzo S.A. (Adeza), Cabanas, Puentedeume (La Coruna), Spain. (*Ingots and small castings.*) (EL FERROL.)

Aciéries du Furan, St. Etienne (Loire), France. (*Electric steel castings.*) (MARSEILLES.)

"Acieroy", Aciéries et Fonderies du Doubs, Société Anonyme, Sainte-Suzanne, near Montbéliard (Doubs), France. (*Small electric steel castings.*) (PARIS.)

Acos Villares S.A. Sao Caetano do Sul, Sao Paulo, Brazil. (*Castings, forgings, billets and bars.*) (RIO DE JANEIRO.)

Ahlström, A., Oy, Karhulan Tehtaat, Karhula Bruk, Karhula, Finland. (*Castings.*) (HELSINGFORS.)

Aichi Steel Works, Ltd.
- Chita Plant, Aichi Prefecture, Japan. (*Ingots and forgings.*) (KOBE.)
- Kariya Plant, Aichi Prefecture, Japan. (*Ingots and forgings.*) (KOBE.)

Alco Products, Inc., Latrobe, Pa., U.S.A. (*Ingots and forgings.*) (PITTSBURGH, PA.)

Algoma Steel Corporation, Ltd., Sault St. Marie, Ontario, Canada. (*Billets, bars, angles and plates.*) (TORONTO.)

Allard, Usines & Aciéries, Société Anonyme, Mont-sur-Marchienne, near Charleroi, Belgium. (*Castings.*) (ANTWERP.)

Allard, Usines & Aciéries, Société Anonyme, Turnhout, Belgium. (*Small castings.*) (ANTWERP.)

Altos Hornos de Mexico, S.A., (A.H.M.S.A.), Monclova, Coah., Mexico. (*Plates.*) (TAMPICO.)

Amagasaki Iron & Steel Mfg. Co., Ltd.
- Kure Steel Works, Kure, Japan. (*Ingots, castings and small forgings*) (SHIMONOSEKI.)
- Steel Plant, Amagasaki, Japan. (*Ingots, plates, sections and bars.*) (KOBE.)

American Rolling Mill Co., Middletown, O., U.S.A. (*Castings and forgings.*) (CLEVELAND, O.)

Amsco Italiana S.p.A., Milan, Italy. (*Small castings.*) (MILAN.)

Anderson, Aktiebolaget Abjörn, Svedala, near Malmö, Sweden. (*Castings.*) (MALMÖ.)

Ando Iron Works Co., Ltd., Tokyo, Japan. (*Small forgings.*) (YOKOHAMA.)

Ansaldo S.p.A., Stabilimento Fonderia di Ghisa e Metalli, Genova-Pegli, Italy. (*Forgings.*) (GENOA.)

"ARBED", Aciéries Réunies de Burbach-eich-Dudelange,
- Division de Dommeldange, Dommeldange, Luxembourg. (*Ingots, forgings and castings.*) (ANTWERP.)
- Division de Belval, Esch-sur-Allzette, Luxembourg. (*Ingots, blooms, billets, bars and angle bars.*) (ANTWERP.)
- Division d'Esch, Esch-sur-Allzette, Luxembourg. (*Rolling mills for bars and sections.*) (ANTWERP.)
- Division de Burbach, Sarrebruck,
  - Burbach Works. (*Ingots, billets and sections.*) (SAARBRÜCKEN-SAAR.)
  - Hostenbach Works. (*Plates.*) (SAARBRÜCKEN-SAAR.)

Astilleros y Talleres del Noroeste S.A., El Ferrol del Caudillo, Spain. (*Small forgings.*) (EL FERROL.)

Atlantic Steel Castings Co., The, Chester, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Atlas Steels Company, Welland, Ontario, Canada. (*Ingots and bars.*) (TORONTO.)

Aubert et Duval, Anciens Ets., Aciéries des Ancizes, Puy de Dome, France. (*Ingots, rolled bars and forgings.*) (MARSEILLES.)

August Thyssen-Hütte, A.G., Duisburg-Hamborn, Germany. (*Ingots, billets, sections, bars and thin plates.*) (DUSSELDORF.)

Australian Iron & Steel, Pty., Ltd., Port Kembla, N.S.W. (*Plates, bars, sections and forgings.*) (PORT KEMBLA.)

d'Auxonne, Acieries & Fonderies, Auxonne (Côté d'Or), France. (*Small castings.*) (PARIS.)

Avesta Jernverks Aktiebolag, Avesta, Sweden. (*Plates, sections and castings; also high pressure air receivers.*) (STOCKHOLM.)

Azuma Steel Works, Ltd.
- Azuma Plant, Tokyo, Japan. (*Ingots for plate.*) (YOKOHAMA.)
- Senju Plant, Tokyo, Japan. (*Rolling mills for plates.*) (YOKOHAMA.)

Babcock & Wilcox, Sociedad Espanola de Construcciones.
*Head Office:* Calle Ercilla 1, Bilbao, Spain.
*Works:* Galindo-San Salvador Del Valle, Vizcaya, Spain. (*Castings, ingots and forgings.*) (BILBAO.)

Bakker, N.V., Machinefabriek-Staalgieterij, Ridderkerk, Holland. (*Ingots and castings.*) (ROTTERDAM.)

Basconia, Compañia Anonima, Bilbao, Spain. (*Plates, sections and bars.*) (BILBAO.)

Bergische Stahlindustrie K.G., Remscheid, Germany. (*Castings.*) (DUSSELDORF.)

Bertoli fu Rodolfo, S.p.A., Officine Fratelli, Udine, Italy. (*Castings, forgings, bars and sections.*) (TRIESTE.)

Bethlehem Steel Co.,
Bethlehem, Pa., U.S.A. (*Ingots, forgings, bars and sections.*) (PHILADELPHIA.)
Buffalo, N.Y., U.S.A. (CLEVELAND, O.)
Johnstown Plant, Johnstown, Pa., U.S.A. (PITTSBURGH.)
Lebanon, Pa., U.S.A. (*Rolling mills for bars.*) (PHILADELPHIA.)
Los Angeles 54, Cal., U.S.A. (*Round bars.*) (LOS ANGELES.)
Seattle, Wash., U.S.A. (*Sections and bars.*) (SEATTLE.)
Sparrows Point, Md., U.S.A. (*Plates.*) (BALTIMORE.)
Steelton, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Bhartia Electric Steel Co., Ltd., Calcutta, India. (*Castings.*) (CALCUTTA).

Birdsboro Corporation, Birdsboro, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Björneborgs Jernverks Aktiebolag, Björneborg, Sweden. (*Ingots and forgings*). (GOTHENBURG.)

Blanc-Misseron, Société Française des Aciéries de, Quievrechain, Nord, France. (*Ingots and castings.*) (VALENCIENNES.)

Bochumer Verein für Gussstahlfabrikation A.G., Bochum, Germany. (*Ingots, forgings, castings and bars.*) (DUSSELDORF.)

Boel, Usines Gustave, Soc. An., La Louvière, Belgium. (*Ingots, forgings, castings, plates and bars.*) (ANTWERP.)

Bofors, Aktiebolaget, Bofors, Sweden. (*Ingots, forgings, castings and rolled bars.*) (GOTHENBURG.)

Böhler, Gebr. & Co., Aktiengesellschaft, Vienna, Austria.
*Works:* Kapfenberg, Styria. (*Ingots, castings, forgings, bars and plates.*) (VIENNA.)
*Works:* Bruckbach, Low Austria. (*Rolling mills for sections and bars.*) (VIENNA.)

Bolzaneto, Acciaieria e Ferriera di, Genoa, Italy. *Works:* Genoa-Bolzaneto. (*Plates, sections and bars.*) (GENOA.)

Bolzano, S.p.A. Acciaierie di, Bolzano, Italy. (*Ingots, billets, bars and forgings.*) (VENICE.)

Boom, Travaux Métalliques de, Société Anonyme, Boom, Belgium. (*Small castings.*) (ANTWERP.)

Borsig A.G., Berlin-Tegel, Germany. (*Ingots, forgings and castings.*) (BERLIN.)

Boxholms A/B., Boxholm, Sweden. (*Ingots, rolled slabs, blooms, billets, sections and bars.*) (STOCKHOLM.)

Bradford Kendall Ltd.
*Works:* Adelaide, South Australia. (*Castings.*) (ADELAIDE.)
*Works:* Alexandria, Sydney, N.S.W. (*Castings.*) (SYDNEY, N.S.W.)

Brasileira de Usinas Metalurgicas, The Companhia, Usina de Neves, Sao Goncalo, Estado do Rio de Janeiro, Brazil. (*Ingots, sections and bars.*) (RIO DE JANEIRO.)

Breda Fucine S.p.A., Sesto San Giovanni, Milan, Italy. (*Castings and forgings.*) (MILAN.)

Breda Siderurgica Società per Azioni, Sesto San Giovanni, Milan, Italy. (*Ingots and sections.*) (MILAN.)

Breitenbach, Ed., G.m.b.H., Weidenau-Sieg, Germany. (*Castings.*) (COLOGNE.)

Brescia, Acciaieria e Tubificio di, Società Anonima, Brescia, Italy. (*Ingots, sections and bars, castings, weldless drawn or water gas welded tubular material.*) (MILAN.)

Broken Hill Proprietary Co., Ltd.
Rolling Mill, Kwinana, W. Australia. (*Small bars and sections.*) (FREMANTLE.)
Iron & Steel Works, Newcastle, N.S.W. (*Ingots, billets, plates, sections, strip and castings.*) (NEWCASTLE, N.S.W.)
Steel Foundry and Rolling Mill, Whyalla, S. Australia. (*Castings, bars and sections.*) (WHYALLA.)

Burlington Steel Company, Division of States Steel Industries, Ltd., Hamilton, Ontario, Canada. (*Small sections and bars.*) (TORONTO.)

Burmeister & Wain's Maskin-og Skibsbyggeri, Aktieselskabet, Copenhagen, Denmark. (*Ingots, forgings and castings.*) (COPENHAGEN.)

Burn & Co., Ltd., Howrah, India. (*Castings.*) (CALCUTTA.)

Byers Company, A.M., Admin. Office:– Clark Building, Pittsburg 22, Pa., U.S.A.
Economy, Pa., (*Plates, bars and ingots for forging.*) (PITTSBURGH.)

Caleotto, Acciaieria e Ferriera del, S.p.A., Lecco, Italy. (*Ingots, castings, bars, small sections and small forgings.*) (MILAN.)

Canada Foundries & Forging, Ltd., Welland, Ontario, Canada. (*Forgings.*) (TORONTO.)

Canadian Steel Foundries Ltd., Longue Pointe, Montreal, P.Q., Canada. (*Castings.*) (MONTREAL.)

Canadian Sumner Iron Works Ltd., Vancouver, B.C. (*Small castings.*) (VANCOUVER.)

Canadian Unitcast-Steel, Ltd., Sherbrooke, P.Q., Canada. (*Castings.*) (MONTREAL.)

Cantieri Del Tirreno, S.p.A., Riva Trigoso, Genoa, Italy. (*Small forgings.*) (GENOA.)

Cantieri Navali Riuniti. *Head Office* : Genoa. *Works:* Cantiere Navale ed Officine Meccaniche di Ancona. (*Small castings.*) (MILAN.)

Ceretti, Pietro Maria, S.p.A., Ferriera Dell'Ossola-Villadossola, Italy. (*Castings.*) (MILAN.)

Charleroi, Société Anonyme de la Fabrique de Fer de, Charleroi, Belgium. (*Ingots and plates.*) (ANTWERP.)

Chiers, Société des Hauts-Forneaux de la, Forges de Vireux Molhain, Vireux, Ardennes, France. (*Plates, sections and bars.*) (VALENCIENNES.)

Christiania Spigerverk, Oslo, Norway. (*Ingots and bars, also rivet bars.*) (OSLO.)

Chubu Steel Plate Co. Ltd., Nakagawa Works, Nagoya, Japan. (*Ingots and plates.*) (KOBE.)

Clabecq, Société Anonyme Forges de, Clabecq, Belgium. (*Ingots, plates, bars and sections.*) (ANTWERP.)

Cockerill-Ougrée, Société Anonyme, Seraing, Belgium.
*Works:* Division Centre. (*Ingots, blooms, billets, slabs and plates.*) (ANTWERP.)
*Works:* Division Ouest. (*Ingots, blooms, billets, plates, sections, castings and forgings.*) (ANTWERP.)

Colorado Fuel & Iron Corporation, Minnequa Works, Pueblo, Colorado, U.S.A. (*Ingots, bars and small sections.*) (CLEVELAND, O.)

"COMETNA" Companhia Metalurgica Nacional, S.A.R.L., Amadora, Portugal. (*Castings.*) (LISBON.)

Commonwealth Steel Co., Ltd., Waratah, Newcastle, N.S.W. (*Castings and forgings.*) (NEWCASTLE, N.S.W.)

Compagnie des Ateliers et Forges de la Loire.
Usine des Dunes, Malo les Bains (Nord), France. (*Ingots, billets, blooms, bars and forgings.*) (VALENCIENNES.)
Usines de l'Ondaine, Firmigny (Loire), France. (*Ingots, billets, blooms, bars, castings and forgings.*) (MARSEILLES.)
Usines de l'Ondaine, Unieux (Loire), France. (*Forgings.*) (MARSEILLES.)
Usines de St. Chamond, St. Chamond (Loire), France. (*Forgings and plates.*) (MARSEILLES.)
Usines de St. Etienne, St. Etienne (Loire), France. (*Plates.*) (LYONS.)

Compagnie Générale des Aciers, Société Anonyme, Thy-le-Château, Belgium. (*Castings.*) (ANTWERP.)

Companhia Siderurgica Nacional, Volta Redonda, Estado do Rio de Janeiro, Brazil. (*Plates and sections.*) (RIO DE JANEIRO.)

Compañia Auxiliar de Ferrocarriles, Beasain, Guipuzcoa, Spain. (*Small castings and forgings.*) (BILBAO.)

Construcciones Agricolas, Sociedad Anonima de, (S.A.C.A.), Sevilla, Spain. (*Castings.*) (CADIZ.)

Crane-Orion S.p.A., Porto Industriale, Trieste, Italy. (*Forgings and castings.*) (TRIESTE.)

Creusot, Société des Forges et Ateliers du, (S.F.A.C.), Usines Schneider, Le Creusot, France. (*Ingots, forgings, castings, plates and sections.*) (PARIS.)

Crucible Steel Company of America, 4, Gateway Center, P.O. Box 88, Pittsburgh 30, Pa., U.S.A.
Midland Plant, Midland, Pa. (*Ingots, slabs, billets, universal mill plates, hot rolled and cold drawn bars.*) (PITTSBURGH.)

Crucible Steel Company of Canada, Ltd., Sorel, P.Q., Canada. (*Castings.*) (MONTREAL.)

Daido Steel Co., Ltd.
Chita Works, Aichi Prefecture, Japan. (*Ingots, billets and bars.*) (KOBE.)
Hoshizaki Works, Nagoya, Japan. (*Ingots and bars.*) (KOBE.)
Shibukawa Works, Shibukawa, Japan. (*Ingots, small forgings and bars.*) (YOKOHAMA.)
Tsukiji Works, Nagoya, Japan. (*Ingots, forgings and castings.*) (KOBE.)

Dalmine S.p.A. *Head Office:* Milan, Italy.
Dalmine Costa Volpino, Bergamo. (*Seamless tubes.*) (MILAN.)
Dalmine Works, Bergamo. (*Ingots and seamless tubes.*) (MILAN.)

Danske, (Det), Staalvalsevaerk A/S, Frederiksvaerk, Denmark. (*Plates, sections and bars.*) (COPENHAGEN.)

Date Seiko Co., Ltd., Tokyo, Japan. (*Castings.*) (YOKOHAMA.)

Davies & Baird Pty. Ltd., 227, Brunswick Road, Brunswick, Melbourne 10, Australia. (*Castings.*) (MELBOURNE.)

de Roll, Société des Usines de Louis, Gerlafingen, Switzerland. (*Ingots, round bars and forgings.*) (WINTERTHUR.)

De Wendel et Cie., S/A., Hayange, Moselle, France.
Usine de Fenderié. (*Plates.*) (SAAR.)
Usine de St. Jacques. (*Sections.*) (SAAR.)

Decker, Gebrüder, Betrieb 1, Eisen- & Stahlgiesserei, Nürnberg 2, Ostendstr. 84. (*Electric steel castings.*) (AUGSBURG.)

Dembiermont & Cie., Maurice, Hautmont (Nord), France. (*Forgings.*) (VALENCIENNES.)

Deusto, S.A., Talleres de,
*Works:* Deusto, Bilbao, Spain. (*Castings.*) (BILBAO.)
*Works:* Luchana, Bilbao, Spain. (*Ingots, castings and small forgings.*) (BILBAO.)

Deutsche Edelstahlwerke A.G., Krefeld, Germany. (*Ingots, castings, forgings and rolled materials.*) (DUSSELDORF.)

Deutsche Gerätebau G.m.b.H., Werk Stahl u., Eisengiesserei Schubeis, Schwelm, Germany. (*Castings.*) (DORTMUND.)

Dikkers, G., & Co., N.V., Hengelo, Holland. (*Small castings.*) (AMSTERDAM.)

Dingler, Karcher & Cie., G.m.b.H., Saarbrücken, Saar. (*Castings.*) (SAARBRÜCKEN-SAAR.)

Dingler, Karcher & Cie., G.m.b.H., Saarländisches Stahlwerk, Worms/Rhein, Germany. (*Castings.*) (MANNHEIM.)

Dodge Steel Company, Tacony, Philadelphia, Pa., U.S.A. (*Small castings.*) (PHILADELPHIA.)

Dominion Foundries & Steel Ltd., Hamilton, Ontario, Canada. (*Ingots, plates and castings.*) (TORONTO.)

Dominion Steel & Coal Corporation Ltd.,
Montreal Works, 5870, St. Patrick Street, Montreal, Canada. (*Angles, bars and rivets.*) (MONTREAL.)
Trenton Works, Trenton, N.S., Canada. (*Forgings.*) (HALIFAX, N.S.)
Sydney Works, Sydney, N.S., Canada. (*Ingots, billets and sections.*) (HALIFAX, N.S.)

Donegal Steel Foundry Company, 601, East Market Street, Marietta, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Dortmund - Hoerder Hüttenunion, A.G., Dortmund, Germany.
Dortmund-Hoerde Works. (*Ingots, plates, and castings.*) (DORTMUND.)
Dortmund Works. (*Bars, sections and forgings.*) (DORTMUND.)

Drammens Jernstoberi & Mek-Verksted, A/S, Drammen, Norway. (*Small castings.*) (OSLO.)

Dunswart Iron & Steel Works, Ltd., Benoni, South Africa. (*Castings, ingots, billets and small sections.*) (VEREENIGING.)

Duro-Felguera, Sociedad Metalúrgica, La Felguera, Asturias, Spain. (*Ingots, billets, castings, plates and sections.*) (GIJON.)

Echevarria, Sociedad Anonima, Bilbao, Spain. (*Small sections and bars, small forgings and ingots.*) (BILBAO.)

Echeverria, Patricio, S.A., Legazpia, Spain. (*Ingots, blooms and forgings.*) (BILBAO.)

Egyptian Iron & Steel Co., S.A.E., Helwan, U.A.R. (*Plates.*) (PORT SAID.)

Eisen-und Stahlwerk Pleissner G.m.b.H., Herzberg/Harz, Germany. (*Castings.*) (HANOVER.)

Eisenwerk Geweke, R. & C. R. Lange K.G., Hagen-Haspe, Germany. (*Electric steel castings.*) (DORTMUND.)

Eisenwerk Rödinghausen K.G., Lendringsen Krs., Iserlohn, Germany. (*Castings.*) (DORTMUND.)

"ELCANO", Empresa Nacional, Factoria de Manises, Valencia, Spain. (*Castings and forgings.*) (VALENCIA.)

Electrodos y Aceros S.A., Boō, Santander, Spain. (*Castings.*) (BILBAO.)

Ellerbrock, Hans, Stahlgiesserei und Maschinenfabrik, Hamburg, Germany. (*Castings.*) (HAMBURG.)

Empire Steel Castings Inc., Reading, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Empresa Nacional Bazan, El Ferrol del Caudillo, Spain. (*Castings.*) (EL FERROL.)

Empresa Nacional Siderurgica, S.A., (ENSIDESA), Avilés, Spain. (*Ingots, slabs and billets for re-rolling, plates and sections.*) (GIJON.)

Enterprise Engine & Foundry Co., South City, Cal., U.S.A. (*Castings.*) (SAN FRANCISCO.)

Erie Forge Co., Erie, Pa., U.S.A. (*Ingots, forgings and castings.*) (CLEVELAND, O.)

Eschweiler Bergwerks-Verein Hüttenbetriebe, Eschweiler-Aue, Germany. (*Ingots and seamless tubes.*) (COLOGNE.)

Esco Ltd., Port Coquitlam, B.C., Canada. (*Castings.*) (VANCOUVER.)

Española de Construccion Naval, Sociedad.
Reinosa, near Santander, Spain. (*Ingots, forgings, castings, plates and sections.*) (BILBAO.)
Sestao, near Bilbao, Spain. (*Small castings, ingots and forgings.*) (BILBAO.)
San Carlos Factory, San Fernando, Cadiz, Spain. (*Forgings and castings.*) (CADIZ.)

Euskalduna, Compañia, Talleres de Elorrietta, Bilbao, Spain. (*Castings.*) (BILBAO.)

F.A.S.E.F., S.p.A., Fonderie Acciaio Scabar e Figli, Porto Industriale, Trieste, Italy. (*Small castings.*) (TRIESTE).

Fabrica de Mieres, Mieres, Asturias, N. Spain. (*Sections, bars and plates up to 15 mm. in thickness.*) (GIJON.)

Fabrica Italiana Tubi, Società per Azioni, Sestri-Levante, Italy. (*Ingots, billets and weldless rolled and drawn tubes.*) (GENOA.)

Fagersta Bruks Aktiebolag, Fagersta, Sweden (Brukskoncernen).
*Works :* Fagersta. (*Blooms, billets, forgings, rolled bars and electric resistance welded tubes.*) (STOCKHOLM.)
*Works :* Forsbacka. (*Blooms, billets, forged and rolled bars.*) (STOCKHOLM.)
*Works :* Horndal. (*Bars and sections.*) (STOCKHOLM.)
*Works :* Osterbybruk. (*Castings, forgings and rolling mill for bars.*) (STOCKHOLM.)

Faggian, Acciaierie Elettriche Pio, Soc. per Azioni, La Spezia, Italy. (*Small castings.*) (LA SPEZIA.)

Falck, Acciaierie e Ferriere Lombarde. *Head Office & Works :* Milan, Italy. (*Weldless rolled or drawn tubes.*) (MILAN.)
"Concordia". *Works :* Sesto San Giovanni. (*Rolling mills for plates.*) (MILAN.)
"Unione". *Works :* Sesto San Giovanni. (*Ingots, sections, bars, forgings and castings.*) (MILAN.)

Falk Corporation, Milwaukee, Wis., U.S.A. (*Castings.*) (CLEVELAND, O.)

Ferry-Capitain & Cie., Société, Bussy, près Joinville, Haute-Marne, France. (*Electric steel castings.*) (PARIS.)

Feurs, Fonderies & Acieries Electriques de, Feurs, Loire, France. (*Small castings.*) (MARSEILLES.)

FIAT, Società per Azioni, Sezione Ferriere Piemontesi, Turin, Italy. (*Ingots, plates, sections, also seamless and welded tubes.*) (GENOA.)

FIAT, Società per Azioni, Sezione Industrie Metallurgiche Acciaierie, Turin, Italy. (*Castings.*) (GENOA.)

Finkl, A., & Sons Company, Chicago, Ill., U.S.A. (*Forgings.*) (CLEVELAND, O.)

Fischer, George, Ltd., Schaffhausen, Switzerland. (*Castings.*) (WINTERTHUR.)

Fiskars Oy., A.B.
Aminnefors Works, Aminnefors, Finland. (*Ingots, billets, bars and sections.*) (ÅBO.)
Inha Works, Inha, Finland. (*Rolled bars.*) (ÅBO.)

Fives-Lille-Cail, Société de.
Usine de Fives, Lille (Nord), France. (*Forgings.*) (VALENCIENNES.)
Usine de Denain, Denain (Nord), France. (*Castings, ingots, forgings, blooms, bars and sheets.*) (VALENCIENNES.)

Fonderia Acciaieria Giovanni Mandelli, Turin, Italy. (*Small castings.*) (GENOA.)

Forjas Alavesas S.A., Vitoria, Spain. (*Ingots, rolled bars and forgings.*) (BILBAO.)

Frichs A/S, Aarhus, Denmark. (*Castings.*) (COPENHAGEN.)

Friedrich-Carl-Hütte G.m.b.H., Delligsen uber Alfeld/Heine, Germany. (*Castings.*) (HANNOVER.)

Fuji Iron & Steel Co., Ltd.
*Works:* Hirohata, Himeji City, Japan. (*Ingots, billets, plates and sections.*) (KOBE.)
*Works:* Kamaishi, Japan. (*Sections and bars.*) (YOKOHAMA.)
*Works:* Kawasaki, Japan. (*Rolling mills for strips for electric resistance welded tubes.*) (YOKOHAMA.)
*Works:* Muroran, Hokkaido, Japan. (*Billets, sections and bars.*) (YOKOHAMA.)

Fujinagata Shipbuilding & Engineering Co., Ltd., Osaka, Japan. (*Castings and forgings.*) (KOBE.)

Fukushima Seiko Co., Ltd., Fukushima, Japan. (*Castings.*) (YOKOHAMA.)

Fundiciones Echevarria S.A., Beasain, Guipuzcoa, Spain. (*Ingots, small rolled bars and castings.*) (BILBAO.)

Fundiciones Escorsa S.A., Pi y Margall, 2- Hospitalet de Llobregat, Barcelona, Spain. (*Castings.*) (BARCELONA.)

Fundiciones Ituarte S.A., Bilbao, Spain. (*Small castings.*) (BILBAO.)

Ganz-Mavag Mozdony Vagon es Gepgyar, Budapest, Hungary. (*Castings and forgings.*) (VIENNA.)

General Metals Corporation, Oakland, Cal., U.S.A. (*Castings.*) (SAN FRANCISCO.)

Gennevilliers, Aciéries de, Gennevilliers, Seine, France. (*Castings.*) (PARIS.)

Gilson, Société Anonyme des Usines, La Croyère (Bois d'Haine), Belgium. (*Ingots, blooms, sections, rivet bars and forgings.*) (ANTWERP.)

Go Iron Works, Ltd., Tarui Works, Tarui, Japan. (*Small castings.*) (KOBE.)

Gorizia, S.A. Fonderie Officine di, Gorizia, Italy. (*Small castings.*) (TRIESTE.)

Granite City Steel Co., Granite City, Ill., U.S.A. (CLEVELAND, O.)

Great Lakes Steel Corporation, Division of National Steel Corporation, Ecorse, Detroit 29, Michigan, U.S.A. (*Ingots, billets, bars, slabs, plate, blooms, sheet and coiled strip.*) (CLEVELAND.)

Gresele, Acciaierie Valbruna di Ernesto, Vicenza, Italy. (*Castings, bars, sections and forgings.*) (VENICE.)

Guérigny, Forges Nationales de la Chaussade à Nievre, France. (*Ingots, bars, forgings and castings.*) (PARIS.)

Gueugnon, Forges de, Gueugnon, (S & L), France. (*Rolling mill for plates.*) (PARIS.)

Gussstahlwerk Carl Bönnhoff, Wetter/Ruhr, Germany. (*Castings.*) (DORTMUND.)

Gussstahlwerk Oberkassel A.G., Düsseldorf-Oberkassel, Germany. (*Castings.*) (DUSSELDORF.)

Gussstahlwerk Risch K.G., Bergisch-Gladbach, Germany. (*Electric steel castings.*) (COLOGNE.)

Gussstahlwerk Witten A.G., Witten (Ruhr), Germany. (*Ingots, billets, sections, bars and forgings.*) (DORTMUND.)

Gussstahlwerk Wittman A.G., Hagen-Haspe, Germany. (*Castings.*) (DORTMUND.)

Gutehoffnungshütte Sterkrade A.G., Werk Sterkrade, Oberhausen-Sterkrade, Germany. (*Forgings.*) (DUSSELDORF.)

Hachette & Driout, S.A. des Anciens Etablissements, St. Dizier, Hte. Marne, France. (*Castings.*) (PARIS.)

Hadfields Steel Works, Ltd., Alexandria, Sydney, N.S.W. (*Castings and forgings.*) (SYDNEY.)

Hadfields (W.A.) 1934 Ltd., Perth, Western Australia. (*Castings.*) (FREMANTLE.)

HADIR, Société des Haut-Fourneaux et Aciéries de Differdange-St. Ingbert-Rumelange, Differdange Works, Luxembourg. (*Sections and bars.*) (ANTWERP.)

Hainaut-Sambre, Société Métallurgiques, S.A., Couillet, Belgium.
Division de Couillet. (*Ingots, blooms, bars, forgings and castings.*) (ANTWERP.)
Division de Montignies et Chatelineau. (*Rolling mill.*) (ANTWERP.)

Haine St. Pierre et Lesquin, Aciéries de, Société Anonyme, Haine St. Pierre, Belgium. (*Castings.*) (ANTWERP.)
Lesquin-lez-Lille (Nord), France. (*Castings.*) (VALENCIENNES.)

Hakodate Dock Co., Ltd., Hakodate Shipyard, Hakodate, Japan. (*Small forgings and castings.*) (YOKOHAMA.)

Hallstahammar Aktiebolag, Hallstahammar, Sweden. (*Bars.*) (STOCKHOLM.)

Hatakeyama Iron Works Co., Ltd., Komatsugawa Works, Tokyo, Japan. (*Small forgings.*) (YOKOHAMA.)

Helsingors Skibsvaerft-og Maskinbyggeri A/S, Aktieselskabet, Elsinore, Denmark. (*Ingots, forgings and castings.*) (COPENHAGEN.)

d'Hennebont, Forges, Hennebont, Morbihan, France. (*Castings.*) (NANTES.)

Henricot, Usines Emile, Court St. Etienne, Belgium. (*Castings.*) (ANTWERP.)

Hierros y Aceros Industriales S.A., San Adrian de Besos, Barcelona, Spain. (*Small castings.*) (BARCELONA.)

Hindustan Steel Ltd.,
Rourkela, Orissa, India. (*Ingots, slabs and plates.*) (CALCUTTA.)
Durgapur Steel Plant, West Bengal, India. (*Blooms, billets, bars and sections.*) (CALCUTTA.)

Bhilai Steel Project, Bhilai, Madhya Pradesh, India. (*Ingots, blooms, billets and sections.*) (CALCUTTA.)

d'Hirson S.A., Aciéries, Hirson, Aisne, France. (*Castings.*) (VALENCIENNES.)

Hitachi, Ltd.,
Hitachi Works, Hitachi, Japan. (*Castings.*) (YOKOHAMA.)
Kasado Works, Kudamatsu, Japan. (*Castings and forgings.*) (SHIMONOSEKI.)
Katsuta Works, Katsutashi, Ibaragi-ken, Japan. (*Ingots, forgings and castings.*) (YOKOHAMA.)

Hitachi Metal Industries, Ltd.,
Yasugi Works, Yasugi, Japan. (*Ingots and bars.*) (KOBE.)
Tobata Works, Tobata, Japan. (*Castings.*) (SHIMONOSEKI.)

Hitachi Shipbuilding & Engineering Co., Ltd.,
Chikko Shipyard, Osaka, Japan. (*Castings and forgings.*) (KOBE.)
Innoshima Shipyard, Innoshima, Japan. (*Forgings and small castings.*) (KOBE.)

Hoesch-Westfalenhütte A.G., Dortmund, Germany. (*Ingots, billets, plates, bars and sections.*) (DORTMUND.)

Hokuriku Kogyo Co., Ltd., Sanjo Plant, Sanjo, Niigata Prefecture, Japan. (*Small forgings.*) (YOKOHAMA.)

Howa Machinery, Ltd., Inazawa Plant, Aichi Prefecture, Japan. (*Castings.*) (KOBE.)

Hults Bruk A.B., Aby, Sweden. (*Castings.*) (STOCKHOLM.)

Huta 1-Go Maja, Gliwice, Poland. (*Forgings.*) (KATOWICE.)

Huta Baildon, Katowice, Poland. (*Ingots, forgings and bars.*) (KATOWICE.)

Huta Batory, Chorzow-Batory, Poland. (*Forgings, plates and tubes.*) (KATOWICE.)

Huta Bieruta, Czestochowa, Poland. (*Seamless tubes.*) (KATOWICE.)

Huta Bobrek, Bytom, Poland. (*Ingots, slabs and blooms.*) (KATOWICE.)

Huta im. M. Buczka, Sosnowiec, Poland. (*Seamless tubes.*) (KATOWICE.)

Huta Dzierzynskiego, Dabrowa Gornicza, Poland. (*Billets, sections and bars.*) (KATOWICE.)

Huta Florian, Swietochlowice, Poland. (*Angles and bars.*) (KATOWICE.)

Huta Jednosc, Siemianowice Slaskie, Poland. (*Ingots and seamless tubes.*) (KATOWICE.)

Huta Kosciuszko, Chorzow, Poland. (*Billets, blooms, sections and rivet bars.*) (KATOWICE.)

Huta Labedy, Labedy, Poland. (*Flats and sections.*) (KATOWICE.)

Huta Lenina, Krakow, Poland. (*Ingots, slabs, plates up to 12 mm.*) (KATOWICE.)

Huta Malapanew, Ozimek k/Opola, Poland. (*Castings.*) (KATOWICE.)

Huta Nowotki, Ostrowiec Swietokrzyski, Poland. (*Sections.*) (KATOWICE.)

Huta Pokoj, Ruda Slaska, Poland. (*Plates and sections.*) (KATOWICE.)

Huta Stalowa Wola, Stalowa Wola, Poland. (*Castings, forgings, plates and sections.*) (KATOWICE.)

Huta Z.M.G.S., Elblag, Poland. (*Castings.*) (GDANSK.)

Huta Zawiercie, Zawiercie, Poland. (*Flats and bars.*) (KATOWICE.)

Hutten-und Bergwerke Rheinhausen A.G., Hüttenwerk Rheinhausen, Rheinhausen, Germany. (*Bars and sections only.*) (DUSSELDORF.)

Hüttenwerk Oberhausen A.G., Oberhausen, Germany. (*Ingots, plates, sections and bars.*) (DUSSELDORF.)

Hüttenwerk Salzgitter A.G., Salzgitter - Drütte, Germany. (*Ingots, plates, bars and sections.*) (HANOVER.)

Hüttenwerke Siegerland A.G., Niederschelden, Germany. (*Ingots and slabs.*) (COLOGNE.)

Ilseder Hütte A.G., Peine, Germany. (*Ingots, billets, sections and bars.*) (HANOVER.)

d'Imphy, Société Métallurgique,
Acieries d'Imphy (Nièvre), France. (*Ingots, forgings, bars and sections.*) (PARIS.)
Usine de Pamiers (Ariège), France. (*Castings and forgings.*) (MARSEILLES.)

Indian Iron & Steel Co., Ltd., Burnpur Works, Burnpur, West Bengal, India. (*Sections and angles.*) (CALCUTTA.)

Indian Tube Company, (1953) Ltd., Jamshedpur, India. (*Seamless tubes.*) (CALCUTTA.)

Industrial Steels, Ltd., Lidcombe, Sydney, N.S.W., Australia. (*Castings.*) (SYDNEY.)

Industrias Mecanicas, Sociedad Anonima, Barcelona, Spain. (*Castings.*) (BARCELONA.)

Inland Steel Co., Indiana Harbor, Ind., U.S.A. (*Ingots, blooms, billets and slabs.*) (CLEVELAND, O.)

Interprovincial Steel and Pipe Corporation Ltd., Regina, Saskatchewan, Canada. (*Plates.*) (TORONTO.)

Isaacson Iron Works, P.O. Box 3625, Seattle 14, Wash., U.S.A. (*Ingots.*) (SEATTLE.)

Ishikawajima-Harima Heavy Industries Co., Ltd., Aioi Works, Aioi, Japan. (*Castings and forgings.*) (KOBE.)

Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan. (*Ingots, forgings and castings.*) (YOKOHAMA.)

"ITALSIDER" Alti Forni e Acciaierie Riunite Ilva e Cornigliano S.p.A., Head Office: Via Corsica 4, Genoa, Italy.
S.I.A.C., Genoa. (*Ingots, forgings, plates and castings.*) (GENOA.)
Stabilimento di Bagnoli. (*Ingots, sections and bars.*) (NAPLES.)
Stabilimento Oscar Sinigaglia, Genoa Cornigliano. (*Ingots, slabs and plates.*) (GENOA.)

Stabilimento di Lovere. (*Sections, bars, castings and forgings.*) (MILAN.)
Stabilimento di Marghera. (*Rolling mills for small sections and bars.*) (VENICE.)
Stabilimento di Portovecchio di Piombino. (*Ingots, blooms, sections and bars.*) (LEGHORN.)
Stabilimento di Taranto. (*Rolling mill for plates.*) (NAPLES.)

Izuo Chukosho Co., Ltd., Osaka, Japan. (*Castings.*) (KOBE.)

Jadot, Société Anonyme Etablissements, Beloeil, Belgium. (*Small castings.*) (ANTWERP.)

Japan Special Steel Co., Ltd., Tokyo, Japan. (*Ingots, forgings, blooms, billets and bars.*) (YOKOHAMA.)

Japan Steel Works Ltd.,
Hiroshima Works, Hiroshima, Japan. (*Forgings and castings.*) (SHIMONOSEKI.)
Muroran Works, Muroran, Japan. (*Ingots, forgings, castings and plates.*) (YOKOHAMA.)

Jemappes, Société Anonyme Forges et Laminoirs de, Jemappes, near Mons, Belgium. (*Ingots, blooms and bars.*) (ANTWERP.)

Jeumont, Forges et Ateliers de Constructions Electriques de, Jeumont (Nord), France. (*Castings.*) (VALENCIENNES.)

Jonan Iron Works Co., Ltd., Haneda Works, Tokyo, Japan. (*Small forgings.*) (YOKOHAMA.)

Jones & Laughlin Steel Corporation, Pittsburgh, Pa., U.S.A. (PITTSBURGH.)

K.G.M.-Altalanos Gepipari Igazgatosag, Budapest, Hungary.
*Works:* Öntödei Vallalat 1. sz., Gyára, Budapest. (*Castings.*) (VIENNA.)

K.G.M. Jarmuipari Igazgatosag, Budapest, Hungary.
*Works*: Wilhelm Pieck Vagon es Gepgyar, Gyor. (*Castings.*) (VIENNA.)

K.G.M. Vaskohászati Igazgatóság, Budapest, Hungary.
*Works:* Lenin Kohászati Müvek, Miskole-Diósgyör. (*Ingots, slabs, sections, bars, castings and forgings.*) (VIENNA.)
*Works:* Dunai Vasmü, Dunaujváros. (*Ingots, slabs and plates.*) (VIENNA.)
*Works:* Dunai Vasmü, Lörinci Hengermüve, Budapest. (*Rolling mill for plates.*) (VIENNA.)
*Works:* Ozdi Kohászati üzemek, Ozd. (*Ingots, slabs, plates, sections and bars.*) (VIENNA.)

K.M. Steel Products Pty., Ltd., Brooklyn, Melbourne, Australia. (*Ingots.*) (MELBOURNE.)

Kaiser Steel Corporation, Fontana, Cal., U.S.A. (*Ingots and plates.*) (LOS ANGELES.)

Kakegawa Endo Iron Works Co., Ltd., Kakegawa, Japan. (*Forgings.*) (YOKOHAMA.)

Kansai Steel Corp., Sakai, Japan. (*Ingots, bars and flat bars.*) (KOBE.)

Kansai Tekko Co., Ltd., Amagasaki, Japan. (*Small forgings.*) (KOBE.)

Kanthal, A/B, Hallstahammar, Sweden. (*Ingots, billets, bars and castings.*) (STOCKHOLM.)

Kanto Special Steel Works, Ltd., Fujisawa, Kanagawa Pref., Japan. (*Forgings.*) (YOKOHAMA.)

Kawaguchi Kinzoku Kogyo Kabushiki Kaisha, Kawaguchi, Japan. (*Castings*). (YOKOHAMA.)

Kawasaki Dockyard Co., Ltd., Kobe, Japan. (*Castings and small forgings.*) (KOBE.)

Kawasaki Rolling Stock Mfg. Co., Ltd., Kobe, Japan. (*Castings.*) (KOBE.)

Kawasaki Steel Corporation.
Chiba Works, Chiba. (*Slabs and plates.*) (YOKOHAMA.)
Chita Works, Handa City. (*Ingots.*) (KOBE.)
Fukiai Works, Kobe. (*Ingots, blooms, sections and plates.*) (KOBE.)
Hyogo Works, Kobe. (*Castings and forgings.*) (KOBE.)
Nishinomiya Works, Nishinomiya. (*Ingots and plates.*) (KOBE.)

Kilby Steel Co., Furnace Division, Anniston, Alabama, U.S.A. (*Ingots.*) (MOBILE.)

Kinka Kikai Co., Ltd., Gifu, Japan. (*Castings.*) (KOBE.)

Klafreströms Bruk, A/B., Klavreström, Sweden. (*Small castings.*) (GOTHENBURG.)

Klinger, Rich., Aktiengesellschaft, Gumpoldskirchen, near Vienna, Austria. (*Small castings.*) (VIENNA.)

Klöckner-Werke A.G.,
*Works:* Georgsmarienwerke, Osnabruck, Germany. (*Ingots, bars, forgings and castings.*) (HANNOVER.)
*Works:* Hütte Bremen, Germany. (*Plates.*) (BREMEN.)
*Works:* Hütte-Haspe, Hagen-Haspe, Germany. (*Ingots, plates, bars and sections.*) (DORTMUND.)
*Works:* Mannstaedt-Werke, Troisdorf, Germany. (*Rolling mills for sections.*) (COLOGNE.)

Knorr-Bremse G.m.b.H., Volmarstein-Schmandbruch, Germany. (*Castings.*) (DORTMUND.)

Kobe Steel Works, Ltd., Kobe, Japan. (*Ingots, blooms, billets, bars and castings.*) (KOBE.)

Kobe Steel Works, Ltd., Takasago Plant, Takasago, Japan. (*Ingots, forgings and castings.*) (KOBE.)

Kockums Jernverk, Kallinge, Sweden. (*Castings.*) (MALMO.)

Kohlswa Jernverks Aktiebolag. (*Ingots, forgings and castings.*) (STOCKHOLM.)

Kokko Steel Works, Ltd., Osaka, Japan. (*Angles, bars and castings.*) (KOBE.)

Kokoku Chuko-sho K.K., Osaka, Japan. (*Castings.*) (KOBE.)

Komatsu Manufacturing Co., Ltd.,
Komatsu, Japan. (*Castings.*) (KOBE.)
Osaka Plant, Hirakata, Osaka Prefecture, Japan. (*Castings.*) (KOBE.)

Koninklijke Demka Staalfabrieken N.V., Utrecht, Holland. (*Ingots, forgings, blooms, billets and castings; also rivet bars.*) (AMSTERDAM.)

Koninklijke Nederlandsche Hoogovens & Staalfabrieken N.V. (Royal Netherlands Blast-furnaces & Steel Works, Ltd.), Ymuiden, Holland. (*Plates and sections.*) (AMSTERDAM.)

Kotobuki Kogyo Co., Ltd., Hiro Works, Kure, Japan. (*Castings.*) (SHIMONOSEKI.)

Krauss-Maffei A.G., München-Allach, Germany. (*Castings.*) (AUGSBURG.)

Kubota Iron & Machinery Works Ltd., Hirakata Plant, Hirakata, Osaka, Japan. (*Castings.*) (KOBE.)

Kure Shipbuilding & Engineering Co., Ltd., Kure, Japan. (*Small forgings.*) (SHIMONOSEKI.)

Kureha Seiko Co. Ltd., No. 1 5-Chome Takeshima-Cho, Nishiyodogawa-Ku, Osaka, Japan. (*Castings.*) (KOBE.)

Kureha Seitetsu Co., Ltd., Toyama, Japan. (*Ingots.*) (YOKOHAMA.)

Kurimoto Iron Works Ltd., Kagaya Works, Osaka, Japan. (*Castings*). (KOBE.)

La Maquinista Terrestre y Maritima, S.A., Barcelona, Spain. (*Castings and forgings.*) (BARCELONA.)

Laminoirs, Société Anonyme des, Hauts-Fourneaux, Forges et Fonderies de la Providence, Hautmont (Nord), France. (*Ingots, plates and sections.*) (VALENCIENNES.)

Larssons, A/B P.S., Gjuteri & Aduceringsverk, Eskilduna, Sweden. (*Castings.*) (STOCKHOLM.)

Lebanon Steel Foundry, Lebanon, Pa., U.S.A. (*Small castings.*) (PHILADELPHIA.)

Leonard-Giot, Société Anonyme Usines & Aciéries, Marchienne-au-Pont, Belgium. (*Castings.*) (ANTWERP.)

Lesjöfors Aktiebolag, Lesjöfors, Sweden. (*Ingots and bars.*) (GOTHENBURG.)

Lindener Eisen-und Stahlwerke G.m.b.H., Hannover-Linden, Germany. (*Ingots and Castings.*) (HANNOVER.)

Llodio, Ltda., Aceros de, Llodio, near Bilbao, Spain. (*Small castings, ingots, forgings and rolled bars.*) (BILBAO.)

Lokomo Oy, Tampere, Finland. (*Ingots, forgings and castings.*) (ÅBO.)

Lorraine-Escaut S.A.,
- Departement Tubes, Usine d'Anzin, Anzin (Nord), France. (*Ingots and weldless rolled or drawn tubes.*) (VALENCIENNES.)
- Usine de Longwy, Section Mont-St.-Martin, Mont-St.-Martin (Meurthe et Moselle), France. (*Sections and plates.*) (SAAR.)
- Usine de Longwy, Section Senelle, Longwy-Bas (Meurthe et Moselle), France. (*Ingots, blooms, bars and sections.*) (SAAR.)
- Usine de Sedan, Sedan (Ardennes), France. (*Plates.*) (VALENCIENNES.)
- Usine de Thionville, Thionville (Moselle), France. (*Forgings.*) (SAAR.)

Los Angeles Steel Casting Co., Los Angeles, Cal., U.S.A. (*Castings.*) (LOS ANGELES.)

Luigi Giudici, Fonderie e Smalterie Rescaldina, Milan, Italy. (*Small castings.*) (MILAN.)

Lukens Steel Company, Coatesville, Pa., U.S.A. (*Plates.*) (PHILADELPHIA.)

Luzuriaga, Victorio, S.A., Pasajes, Guipuzcoa, Spain.
*Works:* Lasarte, Nr. San Sebastian, Guipuzcoa. (*Castings.*) (BILBAO.)

Lynn Macleod Metallurgy Ltd., Thetford Mines, P.Q., Canada. (*Castings.*) (MONTREAL.)

Maekawa Electric Steel Castings Co., Osaka, Japan. (*Castings.*) (KOBE.)

Maitre & Cie, Ets, Colombie-Fontaine, (Doubs), France, *Small castings.*) (PARIS.)

Maizuru Shipbuilding & Eng. Co. Ltd., Maizuru Shipyard, Maizuru, Japan. (*Small forgings and castings.*) (KOBE.)

Makine ve Kimya Endustri, Celik Fabrikasi, Kirikkale, Turkey. (*Ingots, forgings, rolled sections and bars.*) (ISTANBUL.)

Mangolds Engineering, Port Elizabeth, South Africa. (*Small castings.*) (DURBAN.)

Manitoba Rolling Mill Co., Ltd., Selkirk, Manitoba, Canada. (*Billets, bars and sections.*) (MONTREAL.)

Mannesmann A.G.
- Hahnsche Werke, Duisburg-Grossenbaum, Germany (*Bars and electric resistance welded tubes.*) (DUSSELDORF.)
- Huttenwerk Huckingen, Duisburg-Huckingen, Germany. (*Ingots, plates, sections and bars.*) (DUSSELDORF.)

Manufacturas de Acero S.A., Badalona, Barcelona, Spain. (*Small castings.*) (BARCELONA.)

Marine Nationale Indret, Etablissement de la, Loire-Atlantique, France. (*Castings.*) (NANTES.)

Maritime Steel and Foundries, Ltd., New Glasgow, Nova Scotia. (*Small castings.*) (HALIFAX, N.S.)

Marquise, Usines Métallurgiques de, Rinxent, Pas-de-Calais, France. (*Castings.*) (VALENCIENNES.)

Marrel Frères, Société Anonyme des Etablissements, Usine des Etaings, near Rive-de-Gier (Loire), France. (*Ingots, forgings, plates and bars.*) (MARSEILLES.)

Mason & Cox, Ltd., Adelaide, S. Australia. (*Castings.*) (ADELAIDE.)

Material y Construcciones S.A., Barcelona, Spain. (*Castings.*) (BARCELONA.)

Matsuya Kogyo Co., Ltd., Fukuoka, Japan. (*Small forgings.*) (SHIMONOSEKI.)

Maubeuge, Société Anonyme de la Fabrique de Fer de, Louvroil (Nord), France. (*Ingots and plates.*) (VALENCIENNES.)

Maximilianshütte, Eisenwerk-Gesellschaft m.b.H., Sulzbach-Rosenberg, Bavaria, Germany.
- Haidhof Works: (*Ingots, billets, bars, small sections and thin plates.*) (AUGSBURG.)
- Rosenberg Works: (*Ingots and billets.*) (AUGSBURG.)

MECFOND—Officine Meccaniche e Fonderie Napoletane, Naples, Italy. (*Castings.*) (NAPLES.)

Meridionali, Acciaierie e Tubificio, S.p.A., Bari, Italy. (*Castings and weldless rolled or drawn tubes.*) (NAPLES.)

Meridionales, Fonderies, Marseilles, France. (*Castings.*) (MARSEILLES.)

Metal & Steel Factory, Ishapore, West Bengal, India. (*Ingots, blooms, billets and forgings.*) (CALCUTTA.)

Metallurgica Marcora, Busto Arsizio (Varese), Italy (*Weldless rolled and drawn tubes.*) (MILAN.)

Metalurgica Duarte Ferreira S.A.R.L., Tramagal, Portugal. (*Castings.*) (LISBON.)

Meuse, Les Acieries de la, S.A., Cheratte-lez-Liege, Belgium. (*Castings.*) (ANTWERP.)

Meuse, Les Usines à Tubes de la, Flémalle-Haute, Belgium. (*Seamless tubes.*) (ANTWERP.)

Meuse, Société Métallurgique de la, Forges et Aciéries de Stenay, Stenay, Meuse. (*Small castings.*) (VALENCIENNES.)

MIAG (Mühlenbau und Industrie G.m.b.H.), Braunschweig, Germany. (*Castings.*) (HANOVER.)

Midvale-Heppenstall Company, Nicetown, Philadelphia, Pa., U.S.A. (*Forgings.*) (PHILADELPHIA.)

Mineracao Geral do Brazil, Lda., Sao Paulo, Brazil. (*Ingots and weldless tubes.*) (RIO DE JANEIRO.)

Mitsubishi Steel Manufacturing Co., Ltd., Tokyo, Japan.
- Fukugawa Works. (*Billets and bars.*) (YOKOHAMA.)
- Hirota Works. (*Ingots.*) (YOKOHAMA.)
- Oshima Works. (*Rolling mills for billets and bars.*) (YOKOHAMA.)

Mitsubishi Nippon Heavy Industries Ltd., Yokohama Shipyard and Engine Works, Yokohama, Japan. (*Ingots, blooms, small forgings and castings.*) (YOKOHAMA.)

Mitsubishi Shipbuilding and Engineering Co., Ltd.,
- Hiroshima Works, Hiroshima, Japan. (*Ingots, castings and small forgings.*) (SHIMONOSEKI.)
- Nagasaki Works, Nagasaki, Japan. (*Castings and small forgings.*) (NAGASAKI.)
- Shimonoseki Works, Shimonoseki, Japan. (*Small forgings.*) (SHIMONOSEKI.)

Mitsubishi Steel Manufacturing Co., Ltd., Nagasaki Works, Nagasaki, Japan. (*Ingots, blooms, plates, forgings and castings.*) (NAGASAKI.)

Mitsuboshi Iron Works Co., Ltd., Osaka, Japan. (*Small forgings.*) (KOBE.)

Mitsui Miike Machinery Co., Ltd., Miike Works, Omutashi, Japan. (*Castings.*) (SHIMONOSEKI.)

Mitsui Shipbuilding & Engineering Co., Ltd., Tamano, Japan. (*Ingots, forgings and castings.*) (KOBE.)

Mitsumoto Valve Manufacturing Co., Ltd., Domyoji, Osaka, Japan. (*Small forgings and small castings.*) (KOBE.)

Montluçon, Commentry, Société des Forges et Ateliers de, Usines St. Jacques, Montluçon (Allier), France. (*Castings, ingots, forgings, sheets and sections.*) (PARIS.)

Motala Verkstad, A/B, Motala Verkstad, Sweden. (*Ingots, forgings, castings, sections and bars.*) (GOTHENBURG.)

Mukand Iron & Steel Works, Ltd., Kurla, Bombay, 70, India. (*Castings.*) (BOMBAY.)

Nakayama Steel Works, Osaka, Japan. (*Ingots, forgings, and plates up to 25 mm. in thickness.*) (KOBE.)

National Iron & Steel Co., Ltd., Stephen House, Calcutta, 1, India. (*Castings.*) (CALCUTTA.)

National Malleable and Steel Castings Co., Sharon, Pa., U.S.A. (*Castings.*) (PITTSBURGH.)

Nazionale "Cogne", S.p.A. *Head Office:* Turin. *Works:* Aosta. (*Ingots, forgings, plates, sections and bars.*) (GENOA.)

Newport News Shipbuilding & Dry Dock Co., Newport News, Va., U.S.A. (*Castings and forgings.*) (NEWPORT NEWS.)

Nicolacopoulos, G., & Co., Athens, Greece, Steelworks at Eleusis. (*Castings.*) (PIRÆUS.)

Nihon Cast Steel Co., Ltd., Tokyo, Japan. (*Ingots, forgings and castings.*) (YOKOHAMA.)

Niigata Engineering Co., Ltd., Niigata, Japan. (*Castings, ingots and forgings.*) (YOKOHAMA.)

Nippon Chuzo Kabushiki Kaisha, Kawasaki, Japan. (*Ingots and castings.*) (YOKOHAMA.)

Nippon Kokan Kabushiki Kaisha.
- Asano Dockyard, Yokohama, Japan. (*Small forgings.*) (YOKOHAMA.)
- Kawasaki Iron Works, Kawasaki, Japan. (*Tubes, bars and sections.*) (YOKOHAMA.)
- Mizue Ironworks, Kawasaki, Japan. (*Plates up to ½-inch in thickness.*) (YOKOHAMA.)
- Tsurumi Iron Works, Tsurumi, Yokohama, Japan. (*Ingots and plates.*) (YOKOHAMA.)

Nippon Sharyo Seizo Kaisha, Ltd., Nagoya, Japan. (*Castings.*) (KOBE.)

Nippon Stainless Steel Co., Ltd., Naoetsu Works, Niigata, Japan. (*Ingots, forgings and castings.*) (YOKOHAMA.)

Nippon Steel Foundry Co., Ltd., Osaka, Japan. (*Castings.*) (KOBE.)

Nippon Tanko Co., Ltd., Amagasaki, Japan. (*Small forgings.*) (KOBE.)

Nippon Yakin Kogyo Co., Ltd., Kawasaki, Japan. (*Ingots, forgings, bars and sheets.*) (YOKOHAMA.)

Nisshin Seiko Co., Ltd., Shikama Plant, Himeji, Japan. (*Rolled bars.*) (KOBE.)

Nisshin Steel Works, Ltd., Kure Works, Kure, Japan. (*Ingots, blooms, billets and strip.*) (SHIMONOSEKI.)

Nisso Steel Manufacturing Co., Ltd.
- Naoetsu Factory, Naoetsu, Niigata, Japan. (*Ingots.*) (YOKOHAMA.)
- Oshima Plant, Tokyo, Japan. (*Castings, plates, and ingots for forging and plate.*) (YOKOHAMA.)
- Toyama Factory, Toyama City, Japan. (*Ingots and forgings.*) (YOKOHAMA.)

Nittoku Metal Industry Co., Ltd., Tokyo, Japan. (*Small forgings.*) (YOKOHAMA.)

Nordische Stahlwerke, Bach & Co., Neumünster, Germany. (*Castings.*) (KIEL.)

Nordiska Armaturfabrikerna, A/B, Linköping, Sweden. (*Castings.*) (STOCKHOLM.)

Norrbottens Järnverk Aktiebolag, Lulea, Sweden. (*Ingots, slabs, blooms and billets, bars and sections.*) (STOCKHOLM.)

Norsk Jernverk, A/S., Mo-i-Rana, Norway. (*Electric steel ingots, billets, sections and bars.*) (OSLO.)

Nová hut Klementa Gottwalda, národni podnik (New Metallurgical Works of Klement Gottwald, National Corporation), Ostrava-Kunčice, Czechoslovakia. (*Ingots and forgings.*) (VIENNA.)

Nueva Montana Quijano S.A., Nueva Montana, Santander, Spain. (*Castings.*) (BILBAO.)

Oesterreichisch-Alpine Montangesellschaft, Vienna.
*Works:* Donawitz, Styria. (*Sections and strip.*) (VIENNA.)
*Works:* Kindberg, Styria. (*Rolling mills for small sections, bars and strip.*) (VIENNA.)
*Works:* Traisen, Low Austria. (*Castings.*) (VIENNA.)
*Works:* Wördern, Low Austria. (*Ingots.*) (VIENNA.)
*Works:* Zeltweg, Styria. (*Forged bars.*) (VIENNA.)

Ohtani Heavy Industrial Co., Ltd., Amagasaki Plant, Amagasaki, Japan. (*Plates up to 12·5 mm. in thickness.*) (KOBE.)

Okamoto Iron Works Co., Kobe, Japan. (*Forgings.*) (KOBE.)

Okano Valve Manufacturing Co., Ltd., Moji. *Works:* Yukuhashi, Japan. (*Small castings.*) (SHIMONOSEKI.)

Olarra S.A.
*Works:* Erandio, Bilbao Spain. (*Ingots and small bars.*) (BILBAO.)
*Works:* Larrondo, Lujua, Vizcaya, Spain. (*Ingots and rolled bars.*) (BILBAO.)

Olympic Steel Works, Seattle, Wash., U.S.A. (*Castings.*) (SEATTLE.)

Onomichi Anchor Manufacturing Co., Ltd., Onomichi, Japan. (*Castings.*) (KOBE.)

Osaka Chain & Machinery Manufacturing Co., Ltd., Kaizuka Works, Osaka, Japan. (*Small castings.*) (KOBE.)

Osaka Shipbuilding Co., Ltd., Taira Steel Works, Taira City, Fukushima Prefecture, Japan. (*Castings.*) (YOKOHAMA.)

Osaka Steel Casting Co., Ltd., Osaka, Japan. (*Small castings.*) (KOBE.)

Osaka Steel Tube Co., Ltd., Sasebo Works, Sasebo, Japan. (*Seamless tubes.*) (SHIMONOSEKI.)

Otani Steelworks, Ltd., Osaka, Japan. (*Ingots and plates.*) (KOBE.)

Oxelosunds Jarnverk, Oxelosund, Sweden. (*Ingots, rolled slabs and plates.*) (STOCKHOLM.)

Ozuki Seikosho, Ltd., Shimonoseki, Japan. (*Castings.*) (SHIMONOSEKI.)

Pacific States Steel Corporation, Union City, Cal., U.S.A. (*Ingots, sections and bars.*) (SAN FRANCISCO.)

Pacific Steel Castings Co., Berkeley, Cal., U.S.A. (*Castings.*) (SAN FRANCISCO.)

Pacifico, Compañia de Acero del, S.A., Talcahuano, Chile. (*Ingots, plates, bars and sections.*) (SANTIAGO.)

Paderwerk Gebr. Benteler, Schlossneuhaus, Germany. (*Seamless tubes.*) (DORTMUND.)

Paris et d'Outreau, Aciéries de, Société Anonyme, Usine d'Outreau, Pas de Calais, France. (*Castings.*) (VALENCIENNES.)

Paris-Seine, Fonderies et Aciéries de, Usine de la Folie, Avenue de Bobigny, Noisy le Sec (Seine), France. (*Castings.*) (PARIS.)

Penn Steel Castings Co., Chester, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Pennsylvania Steel Foundry and Machine Company, Hamburg, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Pennsylvania Forge, Division of Chemetron Corporation, Tacony, Philadelphia, 35, Pa., U.S.A. (*Forgings.*) (PHILADELPHIA.)

Phoenix-Rheinrohr A.G., Mulheim-Ruhr, Germany. (*Plates.*) (DUSSELDORF.)

Phoenix Steel Corporation.
*Works*: Claymont, Delaware, U.S.A. (*Plates.*) (PHILADELPHIA.)
*Works:* Structural Division, Phoenixville, Pa., U.S.A. (*Sections, bars and rotary forged seamless tubes.*) (PHILADELPHIA.)

Pittsburgh Steel Company, Pittsburgh 30, Pa., U.S.A.
*Works:* Monessen, Pa. (*Ingots, billets and slabs.*) (PITTSBURGH.)
*Works:* Allenport, Pa. (*Rolling mills.*) (PITTSBURGH.)

Pohlig-Heckel-Bleichert, Vereinigte Maschinenfabriken A.G., Abt. Stahlformgiesserei, Werk Heckel, Rohrbach/Saar, Germany. (*Castings.*) (SAARBRÜCKEN-SAAR.)

Pompey, Société des Aciéries de.
Usine de Pompey, Meurthe & Moselle, France. (*Ingots, blooms, billets, plates, angles and round bars.*) (SAARBRÜCKEN-SAAR.)
Usine du Manoir à Pitres, Eure, France. (*Castings.*) (ROUEN.)

Porter, H. K. (France) Acieries Division Marpent, Marpent (Nord), France. (*Castings.*) (VALENCIENNES.)

Pracchi, Fonderie Elettriche O., S.p.A., Milan, Italy. (*Small castings.*) (MILAN.)

Provence, Fonderies et Aciéries de, Marseilles, France. (*Castings.*) (MARSEILLES.)

Providence, Société Anonyme des Forges de la, Marchienne-au-Pont, Belgium. (*Sections, bars, ingots and blooms*). (ANTWERP.)

Quaker Alloy Casting Co., Myerstown, Pa., U.S.A. (*Small castings.*) (PHILADELPHIA.)

Ramnas Bruks Aktiebolag, Ramnas, Sweden. (*Rolling mills for bars.*) (STOCKHOLM.)

Raahe Oy, Raahe, Finland. (*Small castings.*) (ÅBO.)

Raufoss Ammunisjonsfabrikker, Raufoss, Norway. (*Castings.*) (OSLO.)

Republic Steel Corporation, Cleveland, O., U.S.A.
Alabama City, Ala., U.S.A. (MOBILE, ALA.)
Buffalo Plant, Buffalo, N.Y., U.S.A. (CLEVELAND,O.)
Central Alloy District, Massillon Plant, Massillon, O., U.S.A. (CLEVELAND, O.)

Chicago Plant, Chicago, Ill., U.S.A.
*Works:* 118th Street, Chicago. (*Rolling mills.*) East Chicago, Ind. (*Angles and bars.*) (CLEVELAND, O.)
Cleveland District, Cleveland, O., U.S.A. (CLEVELAND, O.)
Corrigan McKinney Plant. (*Ingots, blooms and billets.*)
Upson Nut Plant. (*Round and square bars.*)
Youngstown District, Youngstown, O., U.S.A. (PITTSBURGH.)

Rheinstahl Hüttenwerke, A.G.,
Werk Friedrich Wilhelms-Hütte, Mulheim und Meiderich, Germany. (*Castings.*) (DUSSELDORF.)
Werk Ruhrstahl Henrichshütte, Hattingen, Germany. (*Ingots, plates, forgings and castings.*) (DORTMUND.)
Werk Schalker Verein, Gelsenkirchen, Germany. (*Castings.*) (DUSSELDORF.)

Riken Tanzo Co., Ltd., Maebashi Plant, Maebashi, Japan. (*Small forgings.*) (YOKOHAMA.)

Röchling'sche Eisen-und Stahlwerke G.m.b.H., Völklingen, Saar. (*Castings, ingots, billets, bars and forgings.*) (SAARBRÜCKEN-SAAR.)

Rosenlew, W., & Co., A/B Björneborgs Mekaniska Verkstad, Björneborg, Finland. (*Small castings.*) (ÅBO.)

Rotterdamsche Droogdok Maatschappij, Rotterdam, Holland. (*Ingots, forgings and small castings.*) (ROTTERDAM.)

S.A.F.E. Société Aciers Fins de l'Est, Hagondange, Moselle, France. (*Ingots, blooms, billets, bars, plates and sheet.*) (SAAR.)

S.A.F.A.U. Ferriere Acciaierie di Udine, Udine, Italy. (*Ingots, forgings, blooms, bars and sections.*) (TRIESTE.)

Sambre, Aciéries & Minières de la.
*Works:* Monceau-sur-Sambre, Belgium. (*Sections, bars, billets and blooms.*) (ANTWERP.)
*Works:* Moncheret, near Acoz. (*Rolling mills for bars.*) (ANTWERP.)

Sambre et Meuse, Société Anonyme des Usines et Aciéries de.
Usines de Feignies, Feignies (Nord), France. (*Castings.*) (VALENCIENNES.)
Usines de Saint Brieuc, Cotes-du-Nord, France. (*Small castings.*) (NANTES.)

Sande Giesserei, Sande-Oldenburg, Germany. (*Castings.*) (EMDEN.)

Sandvikens Jernverks Aktiebolag, Sandviken, Sweden. (*Ingots, forgings and tubes.*) (STOCKHOLM.)

"Santa Barbara," Sociedad Industrial Asturiana, Fábricas de Moreda y Gijon, Gijon, Spain. (*Castings and rivet bars.*) (GIJON.)

Sanyo Special Steel Co., Ltd., Himeji, Japan. (*Ingots and forgings.*) (KOBE.)

Sasebo Heavy Industries Co., Ltd., Sasebo, Japan. (*Castings and forgings.*) (NAGASAKI.)

Saut-du-Tarn, Société Anonyme des Forges et Aciéries du, Saint-Juery (Tarn), France. (*Castings.*) (MARSEILLES.)

Scaw Metals, Ltd., Union Junction, Transvaal, S. Africa. (*Rivet bars, small rolled sections and castings.*) (VEREENIGING.)

Schmidt & Clemens, Edelstahlwerk, Berghausen b/Engelskirchen, Bez. Köln, Germany. (*Ingots, forgings, castings and bars.*) (COLOGNE.)

Schoeller-Bleckmann Stahlwerke A.G., Vienna.
*Works:* Muerzzuschlag-Hoenigsberg, Styria. (*Bars.*) (VIENNA.)
*Works:* Ternitz, Low Austria. (*Castings, forgings and bars.*) (VIENNA.)

Schutte, Meyer & Co., G.m.b.H., Letmathe, Westphalia, Germany. (*Small castings.*) (DORTMUND.)

Schütze, A.G., Ludwigshafen-Oggersheim, Germany. (*Electric steel castings.*) (MANNHEIM.)

Seo High Pressure Industry Co., Ltd., Osaka, Japan. (*Small forgings.*) (KOBE.)

Sesto San Giovanni, Acciaierie Elettriche di, S.p.A., Sesto San Giovanni, Milan, Italy. (*Castings.*) (MILAN.)

Sharon Steel Corporation, Roemer Works, Farrell, Pa., U.S.A. (*Ingots, blooms, billets, narrow plates and sections.*) (CLEVELAND.)

Shimizu Tanzo Kabushiki Kaisha, Tokyo, Japan. (*Forgings.*) (YOKOHAMA.)

Shin Mitsubishi Heavy-Industries Ltd.,
Kobe Shipyard and Eng. Works, Kobe, Japan. (*Ingots and small forgings.*) (KOBE.)
Kobe Shipyard, Takasago Factory, Takasago, Japan. (*Forgings.*) (KOBE.)
Mihara Engineering Works, Mihara, Japan. (*Castings and forgings.*) (KOBE.)

Shin Nippon Tanko K.K., Kawasaki, Japan. (*Small forgings.*) (YOKOHAMA.)

S.I.S.M.A. — Società Industrie Siderurgiche Meccaniche & Affini, Villadossola (Novara), Italy. (*Rolled bars and rivets.*) (MILAN.)

SKF. Hofors Bruk, Hofors, Sweden. (*Billets, bars and forgings, and thick walled tubes.*) (STOCKHOLM.)

Smedjebackens Valsverks Aktiebolag, Smedjebacken, Sweden. (*Sections, castings and ingots for re-rolling.*) (STOCKHOLM.)

Società Metallurgica Vittorio Cobianchi S.p.A.
*Head Office:* Milan, Italy.
*Works:* Omegna (NOVARA.) (*Castings*) (MILAN.)

Société Anonyme d'Exploitation des Aciéries de Bordeaux, Pessac, Gironde, France. (*Castings.*) (BORDEAUX.)

Société Anonyme des Forges et Aciéries de Dilling, Dillingen, Sarre. (*Ingots and plates.*) (SAARBRÜCKEN-SAAR.)

Société Belge Griffin S.A., Merxem, Antwerp, Belgium. (*Castings.*) (ANTWERP.)

Société Lorraine de Laminage Continu, Sollac, B.P.13, Serémange, Moselle, France. (*Ingots, slabs and plates.*) (SAAR.)

Société Métallurgique de Normandie, Mondeville, France. (*Ingots, blooms, billets and bars.*) (ROUEN.)

Société Mosellane de Siderurgie, Hagondange (Moselle), France. (*Blooms, billets, bars and sections.*) (SAAR.)

Sollinger Hütte G.m.b.H., Uslar/Solling, Germany. (*Castings.*) (HANNOVER.)

Sorel Industries, Ltd., Sorel, P.Q., Canada. (*Ingots and forgings.*) (MONTREAL.)

South African Iron & Steel Industrial Corporation, Ltd., "Iscor" Works, Pretoria, Transvaal, S. Africa. (*Ingots, billets, sections and thin plates up to $\frac{3}{8}$ inch thick.*) (VEREENIGING.)

"Iscor" Works, Vanderbijl Park, Transvaal, S. Africa. (*Ingots, billets, slabs and plates.*) (VEREENIGING.)

Stahl-u. Röhrenwerke Reisholz A.G., Abt. Oberbilker Stahlwerk, Düsseldorf-Oberbilk, Germany. (*Ingots and forgings.*) (DUSSELDORF.)

Stahlwerk Mannheim A.G., Mannheim-Rheinau, Germany. (*Ingots, forgings and castings.*) (MANNHEIM.)

Stahlwerk Mark, Wengern A.G., Wengern-Ruhr, Germany. (*Ingots and castings.*) (DORTMUND.)

Stahlwerk Südwestfalen, A.G.

Werk Geisweid, Geisweid Kreis Siegen, Germany. (*Ingots, bars, billets, thin plates, sheets and coils.*) (COLOGNE.)

Werk Harkort Eicken, Hagen, Germany. (*Ingots, bars and forgings.*) (DORTMUND.)

Stahlwerke Bochum A.G., Bochum, Germany. (*Castings, forgings, rolled materials and plates.*) (DUSSELDORF.)

Stahlwerke Röchling-Buderus A.G., Wetzlar, Germany. (*Ingots, blooms, billets, bars, forgings and plates.*) (COLOGNE.)

Stål och Maskinaktiebolaget, Upsala, Sweden. (*Ingots.*) (STOCKHOLM.)

Standard Steel Division of Baldwin-Lima-Hamilton Corp., Burnham, Mifflin County, Pa., U.S.A. (*Castings and forgings.*) (PHILADELPHIA.)

Stavanger Electro-Staalverk A.S., Jørpeland, near Stavanger, Norway. (*Castings.*) (BERGEN.)

Steel Company of Australia, Pty. Ltd., Coburg, Melbourne, Australia. (*Castings.*) (MELBOURNE.)

Steel Company of Canada, Hamilton, Ontario, Canada.

*Works* : Hamilton. (*Bars and angles, plates and billets.*) (TORONTO.)

*Works:* Montreal. (*Bars, angles, plates and billets.*) (MONTREAL.)

Steirische Gusstahlwerke, A.G., Vienna. *Works:* Judenburg, Styria, Austria. (*Forgings and bars.*) (VIENNA.)

Stenberg, Oy John, A.B., Helsingfors, Finland. (*Small castings.*) (HELSINGFORS.)

Stora Kopparbergs Bergslags Aktiebolag, Falun, Sweden.

*Works:* Domnarfvet. (*Castings, ingots, sections and plates.*) (STOCKHOLM.)

*Works:* Söderfors. (*Forgings, bars and sections.*) (STOCKHOLM.)

Stramezzi, P., & C., Acciaieria e Ferriera di Crema, Crema, Italy. (*Ingots, bars, small sections and rivets.*) (MILAN.)

Streicher, M., Asperg/Württ, near Stuttgart, Germany. (*Castings.*) (AUGSBURG.)

Stridsberg & Biorck, A.B., Trollhattan, Sweden. (*Castings.*) (GOTHENBURG.)

Strömmens Verksted, A/S, near Oslo, Norway. (*Castings.*) (OSLO.)

Sucesora de Aceros Electricos S.A., Barcelona, Spain. (*Castings.*) (BARCELONA.)

Sud Ouest, Société des Forges et Aciéries du, Bordeaux (Gironde), France. (*Castings and forgings.*) (BORDEAUX.)

Sulzer Bros. Ltd., Winterthur, Switzerland. (*Castings.*) (WINTERTHUR.)

Sumitomo Electric Industries, Ltd., Itami Works, Itami, Hyogo Prefecture, Japan. (*Ingots and small bars.*) (KOBE.)

Sumitomo Machinery Co., Ltd., Niihama, Japan. (*Castings.*) (KOBE.)

Sumitomo Metal Industries, Ltd.

Kokura Steel Works, Kokura, Japan. (*Ingots, billets, bars and sections.*) (SHIMONOSEKI.)

Osaka Steel Works, Osaka. (*Castings, forgings and bars.*) (KOBE.)

Steel Tube Works, Amagasaki, Japan. (*Ingots, forgings, small bars, sections and weldless tubes.*) (KOBE.)

Wakayama Steel Works, Wakayama, Japan. (*Small ingots, plates, seamless tubes and electric resistance welded tubes.*) (KOBE.)

Sunnan Iron Works Co., Ltd., Yaizu, Japan. (*Forgings.*) (YOKOHAMA.)

Surahammars Bruks Aktiebolag, Surahammar, Sweden. (*Plates, forgings and castings.*) (STOCKHOLM.)

Svenska Jarnvagsverkstaderna, A/B, Linköping, Sweden. (*Castings.*) (STOCKHOLM.)

Svenska Kullagerfabriken, A/B,

*Works:* Katrineholm, Sweden. (*Castings.*) (STOCKHOLM.)

*Works:* Hellefors Jernverk, Hällefors, Sweden. (*Ingots and bars.*) (GOTHENBURG.)

Takada Steel Works, Ltd., Takada City, Nara Prefecture, Japan. (*Castings.*) (KOBE.)

Takasaki Metal Industry Co., Ltd., Takasaki Plant, Takasaki, Japan. (*Small castings.*) (YOKOHAMA.)

Tamaris, Société des Ateliers et Fonderies de, Tamaris (Gard), France. (*Castings.*) (MARSEILLES.)

Tassara S.A., Carlo, and Metalcam S.p.A., Breno, Brescia, Italy. (*Ingots, bars and small forgings.*) (MILAN.)

Tata Iron & Steel Co., Ltd., Jamshedpur, India. (*Blooms, billets, bars, plates and sections.*) (CALCUTTA.)

Tata Locomotive & Engineering Co., Ltd., Jamshedpur 4, India. (*Castings.*) (CALCUTTA.)

Teikoku Kokan Seizosho K.K., Osaka, Japan. (*Seamless tubes.*) (KOBE.)

Teil, Fonderies & Aciéries du, Usine du Frayol, Le Teil (Ardeche), France. (*Small castings.*) (MARSEILLES.)

Temple, Acieries du, Saint-Michel de Maurienne, (Savoie) France. (*Rolled and forged bars and billets.*) (MARSEILLES.)

Tennessee Coal & Iron Division, United States Steel Corporation, Birmingham, Ala., U.S.A. *Works:* Ensley, Ala. *Rolling mills, also forgings:* Bessemer and Fairfield, Ala. (MOBILE.)

"Terni" Società per l'Industria e l'Elettricità. *Works:* Terni, Italy. (*Ingots, forgings, castings and plates.*) (NAPLES.)

Titovi Zavodi Litostroj, Ljubljana, Yugoslavia. (*Castings.*) (SPLIT.)

Toho Seiko Kabushiki Kaisha, Nagoya, Japan. (*Castings.*) (KOBE.)

Tohoku Special Steel Works Ltd., Sendai, Japan. (*Ingots, small forgings, billets and bars.*) (YOKOHAMA.)

Tokushu Seiko (Special Steel Mfg.) Co., Ltd., Kawasaki Works, Kawasaki, Japan. (*Ingots, forgings and bars.*) (YOKOHAMA.)

Tokyo Kikai Kabushiki Kaisha, Oshima Cast Steel Works, Tokyo, Japan. (*Castings.*) (YOKOHAMA.)

Tokyo Shibaura Electric Co., Ltd., Turbine Works, Yokohama, Japan. (*Small castings*). (YOKOHAMA.)

Tokyo Steel Casting Co., Ltd., Tokyo, Japan. (*Castings.*) (YOKOHAMA.)

Tokyo Tankosho Co., Ltd., Kawasaki Factory, Kawasaki, Japan. (*Small forgings.*) (YOKOHAMA.)

Topy Industries Ltd.,
- Kanagawa Works, Chigasaki, Japan. (*Ingots for forging, castings.*) (YOKOHAMA.)
- Tokyo Works, Tokyo, Japan. (*Sections.*) (YOKOHAMA.)
- Toyohashi Works, Toyohashi, Japan. (*Ingots, sections and flat bars.*) (KOBE.)

Toshiba Steel Co., Ltd., Tokyo, Japan. (*Castings, small forgings, sections and ingots for forging and plates.*) (YOKOHAMA.)

Tosi, Franco, Società per Azioni, Legnano, Italy. (*Forgings and castings.*) (MILAN.)

Toyo Kikai-Kinzoku Co. Ltd., Tsuchiyama Plant, Akashi, Japan. (*Castings.*) (KOBE.)

Třinecké železárny velké Rijnové socialistické revoluce, národni podnik (Třinec Iron Works Great-Socialistic October Revolution National Corporation), Třinec, Czechoslovakia. (*Ingots, sections, bars and castings.*) (VIENNA.)

Trubia, Fábrica Nacional de, Trubia Asturias, Spain. (*Castings and forgings.*) (GIJON.)

Tsukamoto Sogyo Co., Ltd., Osaka Works, Osaka, Japan. (*Castings.*) (KOBE.)

Turkiye Demir ve Celik Isletmeleri, Karabuk, Turkey (*Ingots, plates, rolled sections and bars.*) (ISTANBUL.)

Tvornica Dizalica I. Ljevaonica "Vulkan", Rijeka II, Yugoslavia. (*Castings.*) (RIJEKA.)

Tweer, Reinhardt, G.m.b.H., Brackwede/Westf., Germany. *Works:* Kracks Nr. Bielefeld. (*Castings.*) (HANNOVER.)

Ube Industries, Ltd., Ube Machinery Works, Ube, Japan. (*Ingots, forgings and castings.*) (SHIMONOSEKI.)

Uddeholms Aktiebolag, Uddeholm, Sweden.
- *Works:* Degerfors. (*Ingots, plates, sections and bars.*) (GOTHENBURG.)
- *Works:* Hagfors. (*Castings.*) (GOTHENBURG.)
- *Works:* Nykroppa. (*Ingots.*) (GOTHENBURG.)
- *Works:* Storfors. (*Seamless tubes.*) (GOTHENBURG.)

Ugine, Aciéries Electriques d', Ugine (Savoie), France. (*Ingots, billets, bars, sections, castings and forgings.*) (MARSEILLES)

União Fabril, Companhia, Barreiro, Portugal. (*Castings.*) (LISBON.)

Union des Aciéries, Société Anonyme, Marcinelle, Charleroi, Belgium. (*Castings.*) (ANTWERP.)

Union Sidérurgique Lorraine, SIDELOR.
- Usine d'Homécourt, Meurthe et Moselle, France. (*Ingots, blooms, billets and plates.*) (SAAR.)
- Usine de Micheville, Villerupt, Meurthe et Moselle, France. (*Ingots, blooms, billets, bars and sections.*) (SAAR.)
- Usine de Rombas, Moselle, France. (*Ingots, blooms, billets, bars and sections.*) (SAAR.)

Union Sidérurgique du Nord de la France.
- Usine de Dunkerque, Dunkerque (Nord). (*Ingots and plates.*) (DUNKERQUE.)
- USINOR GROUPE A.
  - Usines de Denain, Denain (Nord). (*Ingots, plates, sections and castings.*) (VALENCIENNES.)
- USINOR GROUPE B.
  - Usines de Louvroil-Hautmont, Hautmont (Nord). (*Ingots, bars and sections.*) (VALENCIENNES.)
  - Usines de Valenciennes, Valenciennes (Nord). (*Ingots, forgings, blooms, bars and sections.*) (VALENCIENNES.)

Union Steel Corporation of South Africa, Ltd. (Usco).
- *Works:* Vereeniging, Transvaal, South Africa. (*Ingots, billets, small sections, castings and rivet bars.*) (VEREENIGING.)

United States Steel Corporation, Pittsburgh, Pa., U.S.A.
- Clairton Works, Clairton, Pa. (*Ingots, blooms, bars and sections.*) (PITTSBURGH.)

Duquesne Works, Duquesne, Pa. (*Ingots, billets, blooms and bars.*) (PITTSBURGH.)

Fairless Works, Morrisville, Pa. (*Thin plates, bars and sections.*) (PHILADELPHIA.)

Gary Works, Gary, Ind. (*Billets, blooms, plates, sections, bars and forgings.*) (CLEVELAND, O.)

Geneva Works, Provo, Utah. (*Plates.*) (LOS ANGELES.)

Homestead District Works, Pa., including McKees Rock Works. (*Ingots, billets, blooms, slabs, plates, sections and forgings.*) (PITTSBURGH.)

Irvin Works, Dravosburg, Pa. (*Rolling mills for thin plates.*) (PITTSBURGH.)

McDonald Mills, Youngstown. (*Rolling mills for bars and sections.*) (PITTSBURGH.)

Ohio Works, Youngstown. (*Ingots, billets and blooms.*) (PITTSBURGH.)

South Works, South Chicago, Ill. (*Plates, sections and bars.*) (CLEVELAND, O.)

Torrance Works, Torrance, Calif. (*Round bars and sections.*) (LOS ANGELES.)

Uraga Shipbuilding Yard, Uraga Heavy Industries, Ltd., Yokosuka, Japan. (*Castings and small forgings.*) (YOKOHAMA.)

Usinas Siderurgicas de Minas Gerais S.A., Belo Horizonte, Estado de Minas Gerais, Brazil.
*Works:* Ipatinga, Estado de Minas Gerais. (*Ingots, slabs and plates.*) (RIO DE JANEIRO.)

Vallourec, Société, Usine d'Aulnoye, Aulnoye (Nord), France. (*Weldless rolled and drawn tubes.*) (VALENCIENNES.)

Vanderbijl Engineering Corporation, Ltd., Vanderbijl Park, Transvaal, South Africa. (*Castings.*) (VEREENIGING.)

Varde Staalvaerk, Varde, Denmark. (*Ingots and castings.*) (ODENSE.)

Vereinigte Oesterreichische Eisen-und-Stahlwerke, A.G.
*Works:* Liezen, Styria. (*Ingots for forgings, castings.*) (VIENNA.)
*Works:* Linz a.d. Donau, Upper Austria. (*Plates, forgings and castings.*) (VIENNA.)

Vickers Ruwolt Pty., Ltd., Richmond, Melbourne, Australia. (*Castings.*) (MELBOURNE.)

Victoria Machinery Depot Co., Ltd., Victoria, B.C., Canada. (*Castings.*) (VANCOUVER.)

Villa, Giovanni, S.p.A., Officine Meccaniche-Fucinati-Stampati, Milan, Italy. (*Forgings.*) (MILAN.)

Viomichania Chalyvon Ltd., Athens, Greece. (*Castings.*) (PIRÆUS.)

Vitkovické Železárny Klementa Gottwalda, národni podnik (The Vitkovice Steel Works Klement Gottwald, National Corporation), Ostrava 10, Czechoslovakia. (*Castings, forgings, plates, sections, bars and seamless tubes.*) (VIENNA.)

Vizcaya, Altos Hornos de, S.A., Fabrica de Sagunto, Sagunto, Spain. (*Ingots, plates, bars and sections.*) (VALENCIA.)

Vizcaya, Sociedad Altos Hornos de, Bilbao, Spain. (*Ingots, bars, sections, plates and forgings.*) (BILBAO.)

Vuoksenniska Oy Aktiebolag, Imatra Ironworks, Imatra, Finland. (*Ingots, slabs, blooms and billets, bars and sections.*) (HELSINGFORS.)

Waagner-Biro Aktiengesellschaft, Vienna, Austria.
*Works:* Werk C, Vienna. (*Castings.*) (VIENNA.)

Walkers Ltd., Maryborough, Queensland, Australia. (*Forgings and castings.*) (BRISBANE.)

Wärtsilä-koncernen A/B, Dalsbruk Järnverk, Dalsbruk, Finland. (*Ingots, billets, bars, forgings and castings.*) (ÅBO.)

Washington Iron Works, Seattle, Wash., U.S.A. (*Castings.*) (SEATTLE.)

Washino Machine Co., Ltd., Imamura Plant, Aichi Prefecture, Japan. (*Castings.*) (KOBE.)

Watanabe Steel Works Co., Ltd., Tokyo, Japan. (*Castings.*) (YOKOHAMA.)

Welland Electric Steel Foundry Ltd., Welland, Ontario, Canada. (*Small castings.*) (TORONTO.)

Western Canada Steel Ltd., (Vancouver Rolling Mills Ltd.,) Vancouver, B.C., Canada. (*Sections and bars.*) (VANCOUVER.)

Wikmanshytte Bruks A/B, Wikmanshyttan, Sweden. (*Forgings, bars and sections.*) (STOCKHOLM.)

Wood, Alan, Steel Company, Conshohocken, Pa., U.S.A. (*Blooms, billets and plates.*) (PHILADELPHIA.)

Wurth, Société Anonyme des Anciens Etablissements Paul, Luxembourg. (*Castings.*) (ANTWERP.)

Yamato Steel Works, Ltd., Osaka, Japan. (*Ingots, sections and plates.*) (KOBE.)

Yawata Iron & Steel Co., Ltd., Yawata, Japan.
Tobata Plant, Yawata Works, Tobata. (*Plates.*) (SHIMONOSEKI.)
Sakai Works, Sakai, Osaka. (*Rolling mills for sections.*) (KOBE.)
Yawata Plant, Yawata Works, Yawata. (*Plates, sections, ingots and forgings.*) (SHIMONOSEKI.)

Yawata Steel Tube Co., Ltd., Tokyo, Japan. (*Rolling mills for weldless, rolled or drawn tubes.*) (YOKOHAMA.)

Yokoyama Engineering Co., Ltd., Oshima 2nd Works, Tokyo, Japan. (*Castings.*) (YOKOHAMA.)

Yonago Steel Works, Ltd., Yonago, Japan. (*Castings.*) (KOBE.)

Youngstown Sheet and Tube Company.
Brier Hill Works, Youngstown, Ohio, U.S.A.
Campbell Works, Campbell, Mahoning Co., Ohio, U.S.A. (*Ingots, and plates up to* 12·5 *mm. in thickness.*) (PITTSBURGH.)

Zaklady Budowy Przewodow i Armatury, Kielce, Poland. (*Castings.*) (KATOWICE.)

Zaklady Metalurgiczne, Poznan, "Pomet" Poznan, ul Krancowa 15, Poland. (*Castings.*) (GDANSK.)

Zaklady Urzadzen Technicznych "Zgoda", Swietochlowice, Poland. (*Forgings.*) (KATOWICE.)

Závody V. I. Lenina Plzeň, národni podnik (V. I. Lenin Works Pilsen, National Corporation, formerly the Skoda Works, Pilsen), Plzeň, Czechoslovakia. (*Castings and forgings.*) (VIENNA.)

Zelezarna Jesenice, Jesenice, Yugoslavia. (*Plates, bars, sections and small castings.*) (SPLIT.)

Zelezarna Ravne, Ravne na Koroskem, Yugoslavia. (*Castings and forgings.*) (RIJEKA.)

Zelezárny a drátovny Bohumin, národni podnik (Iron Works and Wire Works Bohumin, National Corporation), Bohumin, Czechoslovakia. (*Small sections, bars and seamless tubes.*) (VIENNA.)

Zeljezara Sisak, Sisak-Predgradje, Yugoslavia. (*Seamless tubes.*) (RIJEKA.)

Zeljezara Zenica, Zenica, Yugoslavia. (*Billets, bars, sections and forgings.*) (SPLIT.)

FIRMS IN COUNTRIES OTHER THAN GREAT BRITAIN AND IRELAND (ARRANGED ACCORDING TO SURVEYING DISTRICTS)

**Åbo**

Ahlström, A., Oy, Karhulan Tehtaat, Karhula Bruk, Karhula, Finland. (*Castings.*)

Fiskars Oy, Aktiebolag.
Aminnefors Works, Aminnefors, Finland. (*Ingots, billets, bars and sections.*)
Inha Works, Inha, Finland. (*Rolled bars.*)

Lokomo Oy, Tampere, Finland. (*Ingots, forgings and castings.*)

Raahe Oy, Raahe, Finland. (*Small castings.*)

Rosenlew, W., & Co., A/B Björneborgs Mekaniska Verkstad, Björneborg, Finland. (*Small castings.*)

Wärtsilä-koncernen A/B, Dalsbruks Järnverk, Dalsbruk, Finland. (*Ingots, billets, bars, forgings and castings.*)

**Adelaide**

Bradford Kendall Ltd., Adelaide, South Australia. (*Castings.*)

Mason & Cox Ltd., Adelaide, S. Australia. (*Castings.*)

**Amsterdam**

Dikkers, G., & Co., N.V., Hengelo, Holland. (*Small castings.*)

Koninklijke Demka Staalfabrieken, N.V., Utrecht, Holland. (*Ingots, forgings, blooms, billets and castings; also rivet bars.*)

Koninklijke Nederlandsche Hoogovens & Staalfabrieken N.V. (Royal Netherlands Blast-Furnaces & Steel Works, Ltd.), Ymuiden, Holland. (*Plates and sections.*)

**Antwerp**

Allard, Usines & Aciéries, Société Anonyme, Mont-sur-Marchienne, near Charleroi. (*Castings.*)

Allard, Usines & Aciéries, Société Anonyme, Turnhout. (*Small castings.*)

"ARBED," Aciéries Réunies de Burbach-eich-Dudelange.
Division de Dommeldange, Dommeldange, Luxembourg. (*Ingots, forgings and castings.*)
Division de Belval, Esch-sur-Allzette, Luxembourg. (*Ingots, blooms, billets, bars and angle bars.*)
Division d'Esch, Esch-sur-Allzette, Luxembourg. (*Rolling mills for bars and sections.*)

Baume, Société Anonyme des Forges et Laminoirs de, Haine St. Pierre. (*Ingots, bars and sections.*)

Boël, Usines Gustave, Soc. An., La Louvière. (*Ingots, forgings, castings, plates and bars.*)

Boom, Travaux Métalliques de, Société Anonyme, Boom. (*Small castings.*)

Charleroi, Société Anonyme de la Fabrique de Fer de, Charleroi. (*Ingots and plates.*)

Clabecq, Société Anonyme Forges de, Clabecq, Belgium. (*Ingots, plates, bars and sections.*)

**Antwerp**—*continued*

Cockerill-Ougrée, Société Anonyme, Seraing, Belgium.
*Works:* Division Centre. (*Ingots, blooms, billets, slabs and plates.*)
*Works:* Division Ouest. (*Ingots, blooms, billets, plates, sections, castings and forgings.*)

Compagnie Générale des Aciers, Société Anonyme, Thy-le-Château, Belgium. (*Castings.*)

Gilson, Société Anonyme des Usines, La Croyère (Bois) d'Haine) Belgium. (*Ingots, blooms, sections, rivet bars and forgings.*)

HADIR, Société des Haut-Fourneaux et Aciéries de Differdange - St. Ingbert - Rumelange, Differdange Works, Luxembourg. (*Sections and bars.*)

Hainaut-Sambre, Société Métallurgiques, S.A., Couillet.
Division de Couillet. (*Ingots, blooms, bars, forgings and castings.*)
Division de Montignies et Chatelinlau. (*Rolling mill.*)

Haine St. Pierre et Lesquin, Aciéries de, Société Anonyme, Haine St. Pierre. (*Castings.*)

Henricot, Usines Emile, Court St. Etienne. (*Castings.*)

Jadot, Société Anonyme Etablissements, Beloeil, Belgium. (*Small castings.*)

Jemappes, Société Anonyme Forges et Laminoirs de, Jemappes, near Mons, Belgium. (*Ingots, blooms and bars.*)

Leonard-Giot, Société Anonyme Usines & Aciéries Marchienne-au-Pont. (*Castings.*)

Meuse, Les Acieries de la, S.A., Cheratte-lez-Liege, Belgium. (*Castings.*)

Meuse, Les Usines à Tubes de la, Flémalle-Haute, Belgium. (*Seamless tubes.*)

Providence, Société Anonyme des Forges de la, Marchienne-au-Pont, Belgium. (*Sections, bars, ingots and blooms.*)

Sambre, Aciéries & Minières de la.
*Works :* Monceau-sur-Sambre. (*Sections, bars, billets and blooms.*)
*Works :* Moncheret, near Acoz. (*Rolling mills for bars.*)

Société Belge Griffin S.A., Merxem, Antwerp. (*Castings.*)

Union des Aciéries, Société Anonyme, Marcinelle, Charleroi. (*Castings.*)

Wurth, Société Anonyme des Anciens Etablissements Paul, Luxembourg. (*Castings.*)

**Augsburg**

Decker, Gebrüder, Betrieb 1, Eisen- & Stahlgiesserei, Nürnberg 2, Ostendstr. 84. (*Electric steel castings.*)

Krauss-Maffei, A.G., München-Allach, Germany. (*Castings.*)

**Augsburg**—*continued*

Maximilianshütte, Eisenwerk-Gesellschaft m.b.H., Sulzbach-Rosenberg, Bavaria, Germany.

Haidhof Works. (*Ingots, billets, bars, small sections and thin plates.*)

Rosenberg Works. (*Ingots and billets.*)

Streicher, M., Asperg/Württ, near Stuttgart, Germany. (*Castings.*)

**Baltimore, Md.**

Bethlehem Steel Co., Sparrows Point, Md., U.S.A. (*Plates.*)

**Barcelona**

Fundiciones Escora S.A., Pi y Margall, 2-Hospitalet de Llobregat, Barcelona, Spain. (*Castings.*)

Hierros y Aceros Industriales S.A., San Adrian de Besos, Barcelona, Spain. (*Small castings.*)

Industrias Mecanicas, Sociedad Anonima, Barcelona, Spain. (*Castings.*)

La Maquinista Terrestre y Maritima S.A., Barcelona, Spain. (*Castings and forgings.*)

Manufacturas de Acero S.A., Badalona, Barcelona, Spain. (*Small castings.*)

Material y Construcciones S.A., Barcelona, Spain. (*Castings.*)

Sucesora de Aceros Electricos S.A., Barcelona, Spain. (*Castings.*)

**Bergen**

Stavanger Electro-Staalverk A.S., Jorpeland, near Stavanger, Norway. (*Castings.*)

**Berlin**

Borsig A.G., Berlin-Tegel, Germany. (*Ingots, forgings and castings.*)

**Bilbao**

Acerias y Forjas de Azciotia, Azciotia Juipuzcoa, Spain. (*Ingots and small rolled bars.*)

Babcock & Wilcox, Sociedad Española de Construcciones.

*Head Office:* Calle Ercilla 1, Bilbao.

*Works:* Galindo-San Salvador del Valle. (Vizcaya.) (*Castings, ingots and forgings.*)

Basconia, Compañia Anonima, Bilbao, Spain. (*Plates, sections and bars.*)

Compañia Auxiliar de Ferrocarriles, Beasain, Guipuzcoa, Spain. (*Small castings and forgings.*)

Deusto, S.A. Talleres de,

*Works:* Deusto, Bilbao, Spain. (*Castings.*)

*Works:* Luchana, Bilbao, Spain. (*Ingots, castings and small forgings.*)

Echevarria, Sociedad Anonima, Bilbao, Spain. (*Small sections and bars, small forgings and ingots.*)

Echeverria, Patricio, S.A., Legazpia, Spain. (*Ingots, blooms and forgings.*)

Electrodos y Aceros S.A., Boõ, Santander, Spain. (*Castings.*)

**Bilbao**—*continued*

Española de Construccion Naval, Sociedad.

*Works:* Reinosa, near Santander, Spain. (*Ingots, forgings, castings, plates and sections.*)

*Works:* Sesto, near Bilbao. (*Small castings, ingots and forgings.*)

Euskalduna, Compañia, Talleres de Elorrietta, Bilbao, Spain. (*Castings.*)

Forjas Alavesas, S.A., Vitoria, Spain. (*Ingots, rolled bars and forgings.*)

Fundiciones Echevarria S.A., Beasain, Guipuzcoa, (*Ingots, small rolled bars and castings.*)

Fundiciones Ituarte S.A., Bilbao, Spain. (*Small castings.*)

Llodio, Aceros de, Ltda., Llodio, near Bilbao, Spain. (*Small castings, ingots, forgings and rolled bars.*)

Luzuriaga, Victorio, S.A., Pasajes, Guipuzcoa, Spain.

*Works:* Lasarte, Nr. San Sebastian, Guipuzcoa. (*Castings.*)

Nueva Montana Quijano S.A., Nueva Montana, Santander, Spain. (*Castings.*)

Olarra S.A.

*Works:* Erandio, Bilbao, Spain. (*Ingots and small bars.*)

*Works:* Larrendo, Lujna, Vizcaya, Spain. (*Ingots and rolled bars.*)

Vizcaya, Sociedad Altos Hornos de, Bilbao, Spain. (*Ingots, bars, sections, plates and forgings.*)

**Bombay**

Mukand Iron & Steel Works, Ltd., Kurla, Bombay 70, India. (*Castings.*)

**Bordeaux**

Société Anonyme d'Exploitation des Aciéries de Bordeaux, Pessac, Gironde, France. (*Castings.*)

Sud Ouest, Société des Forges et Aciéries du, Bordeaux (Gironde), France. (*Castings and forgings.*)

**Bremen**

Klöckner-Werke A.G., Hutte Bremen, Germany. (*Plates.*)

**Brisbane**

Walkers Ltd., Maryborough, Queensland, Australia. (*Forgings and castings.*)

**Cadiz**

Construcciones Agricolas, Sociedad Anonima de, (S.A.C.A.), Sevilla, Spain. (*Castings.*)

Española de Construccion Naval, Sociedad, San Carlos Factory, San Fernando, Cadiz, Spain. (*Forgings and castings.*)

**Calcutta**

Bhartia Electric Steel Co., Ltd., Calcutta, India. (*Castings.*)

Burn & Co., Ltd., Howrah, India. (*Castings.*)

**Calcutta**—*continued*

Hindustan Steel Ltd.,
Rourkela, Orissa, India. (*Ingots, slabs and plates.*)
Durgapur Steel Plant, West Bengal, India. (*Blooms, billets, bars and sections.*)
Bhilai Steel Project, Bhilai, Madhya Pradesh, India. (*Ingots, blooms, billets and sections.*)

Indian Iron & Steel Co., Ltd., Burnpur Works, Burnpur, West Bengal, India. (*Sections and angles.*)

Indian Tube Company, (1953) Ltd., Jamshedpur, India. (*Seamless tubes.*)

Metal & Steel Factory, Ishapore, West Bengal, India. (*Ingots, blooms, billets and forgings.*)

National Iron & Steel Co., Ltd., Stephen House, Calcutta, 1, India. (*Castings.*)

Tata Iron & Steel Co., Ltd., Jamshedpur, India. (*Blooms, billets, bars, plates and sections.*)

Tata Locomotive & Engineering Co., Ltd., Jamshedpur 4, India. (*Castings.*)

**Cleveland, O.**

American Rolling Mill Co., Middletown, O., U.S.A. (*Castings and forgings.*)

Bethlehem Steel Co., Buffalo, N.Y., U.S.A.

Colorado Fuel & Iron Corporation, Minnequa Works, Pueblo, Colorado, U.S.A. (*Ingots, bars and small sections.*)

Erie Forge Co., Erie, Pa., U.S.A. (*Ingots, forgings and castings.*)

Falk Corporation, Milwaukee, Wis., U.S.A. (*Castings.*)

Finkl, A., & Sons Company, Chicago, Ill., U.S.A. (*Forgings.*)

Granite City Steel Co., Granite City, Ill., U.S.A.

Great Lakes Steel Corporation, Division of National Steel Corporation, Ecorse, Detroit 29, Michigan, U.S.A. (*Ingots, billets, bars, slabs, plate, blooms, sheet and coiled strip.*)

Inland Steel Co., Indiana Harbor, Ind., U.S.A. (*Ingots, blooms, billets and slabs.*)

Republic Steel Corporation, Cleveland, O., U.S.A.
Buffalo Plant, Buffalo, N.Y., U.S.A.
Central Alloy District, Massillon Plant, Massillon, O., U.S.A.
Chicago Plant, Chicago, Ill., U.S.A.
*Works :* 118th Street, Chicago. *Rolling mills :* East Chicago, Ind. (*Angles and bars.*)
Cleveland District, Cleveland, O., U.S.A.
Corrigan McKinney Plant. (*Ingots, blooms and billets.*)
Upson Nut Plant. (*Round and square bars.*)

Sharon Steel Corporation, Roemer Works, Farrell, Pa., U.S.A., (*Ingots, blooms, billets, narrow plates and sections.*)

United States Steel Company, Pittsburgh, Pa., U.S.A.
Gary Works, Gary, Ind. (*Billets, blooms, plates, sections, bars and forgings.*)
South Works, South Chicago, Ill. (*Plates, sections and bars.*)

**Cologne (Köln)**

Breitenbach, Ed., G.m.b.H., Weidenau-Sieg, Germany. (*Castings.*)

Eschweiler Bergwerks-Verein Hüttenbetriebe, Eschweiler-Aue, Germany. (*Ingots and seamless tubes.*)

Gussstahlwerke Risch K.G., Bergisch-Gladbach, Germany. (*Electric steel castings.*)

Hüttenwerke Siegerland A.G., Niederschelden, Germany. (*Ingots and slabs.*)

Klockner-Werke A.G., Mannstaedt-Werke, Troisdorf, Germany. (*Rolling mills for sections.*)

Schmidt & Clemens, Edelstahlwerk, Bergausen b/Engelskirchen Bez. Köln, Germany. (*Ingots, forgings, castings and bars.*)

Stahlwerke Röchling-Buderus A.G., Wetzlar, Germany. (*Ingots, blooms, billets, bars, forgings and plates.*)

Stahlwerke Südwestfalen, A.G., Werk Geisweid, Geisweid, Kries Siegen, Germany. (*Ingots, bars, billets, thin plates, sheets and coils.*)

**Copenhagen**

Burmeister & Wain's Maskin-og Skibsbyggeri, Aktieselskabet, Copenhagen, Denmark. (*Ingots, forgings and castings.*)

Danske, (Det), Staalvalsevaerk A/S., Frederiksvaerk, Denmark. (*Plates, sections and bars.*)

Frichs A/S, Aarhus, Denmark. (*Castings.*)

Helsingors Skibsvaerft-og Maskinbyggeri A/S., Aktieselskabet, Elsinore, Denmark. (*Ingots, forgings and castings.*)

**Dortmund**

Deutsche Gerätebau G.m.b.H., Werk Stahl u. Eisengiesserei Schubeis, Schwelm, Germany. (*Castings.*)

Dortmund - Hoerder Hüttenunion A.G., Dortmund, Germany.
Dortmund-Hoerde Works. (*Ingots, plates, and castings.*)
Dortmund Works. (*Bars, sections and forgings.*)

Eisenwerk Geweke, R. & C. R. Lange K.G., Hagen-Haspe, Germany. (*Electric steel castings.*)

Eisenwerk Rödinghausen K. G., Lendringsen Krs. Iserlohn, Germany. (*Castings.*)

Gussstahlwerk Carl Bönnhoff, Wetter/Ruhr, Germany. (*Castings.*)

Gussstahlwerk Witten A.G., Witten (Ruhr), Germany. (*Ingots, billets, sections, bars and forgings.*)

Gussstahlwerk Wittman A.G., Hagen-Haspe, Germany. (*Castings.*)

Hoesch-Westfalenhütte A.G., Dortmund, Germany. (*Ingots, billets, plates, bars and sections.*)

Klöckner-Werke A.G., Hütte-Haspe, Hagen Haspe, Germany. (*Ingots, plates, bars and sections.*)

Knorr-Bremse G.m.b.H., Volmarstein-Schmandbruch, Germany. (*Castings.*)

Paderwerk Gebr. Benteler, Schlossneuhaus, Germany. (*Seamless tubes.*)

**Dortmund**—*continued*

Rheinstahl Hüttenwerke A.G., Werk Ruhrstahl Henrichshütte, Hattingen, Germany. (*Ingots, plates, forgings and castings.*)

Schutte, Meyer & Co., G.m.b.H., Letmathe, Westphalia, Germany. (*Small castings.*)

Stahlwerk Mark Wengern A.G., Wengern-Ruhr, Germany. (*Ingots and castings.*)

Stahlwerke Südwestfalen A.G., Werk Harkort Eicken, Hagen, Germany. (*Ingots, bars and forgings.*)

**Dunkerque**

Union Siderurgique du Nord de la France, Usine de Dunkerque, Dunkerque (Nord), France. (*Ingots and plates.*)

**Durban**

Mangolds Engineering, Port Elizabeth, South Africa. (*Small castings.*)

**Dusseldorf**

August Thyssen-Hütte A.G.. Duisburg-Hamborn, Germany. (*Ingots, billets, sections, bars and thin plates.*)

Bergische Stahlindustrie K.G., Remscheid, Germany. (*Castings.*)

Bochumer Verein für Gussstahlfabrikation A.G., Bochum, Germany. (*Ingots, forgings, castings and bars.*)

Deutsche Edelstahlwerke A.G., Krefeld, Germany. (*Ingots, castings, forgings and rolled materials.*)

Gussstahlwerk Oberkassel A.G., Düsseldorf-Oberkassel, Germany. (*Castings.*)

Gutehoffnungshütte Sterkrade A.G., Werk Sterkrade, Oberhausen-Sterkrade, Germany. (*Forgings.*)

Hütten- und Bergwerke Rheinhausen A.G., Hüttenwerk Rheinhausen, Rheinhausen, Germany. (*Bars and sections only.*)

Hüttenwerk Oberhausen, A.G., Oberhausen, Germany. (*Ingots, plates, sections and bars.*)

Mannesmann A.G.,

Hahn'sche Werke, Duisburg-Grossenbaum, Germany. (*Bars and electric resistance welded tubes.*)

Huttenwerk Huckingen, Duisburg-Huckingen, Germany. (*Ingots, plates, sections and bars.*)

Phoenix-Rheinrohr A.G., Mülheim-Ruhr, Germany. (*Plates.*)

Rheinstahl Hüttenwerke A.G.,

Werk Friedrich Wilhelms-Hütte, Mülheim und Meiderich, Germany. (*Castings.*)

Werk Schalker Verein, Gelsenkirchen, Germany. (*Castings.*)

Stahl- u. Röhrenwerke Reisholz A.G., Abt. Oberbilker Stahlwerk, Düsseldorf-Oberbilk, Germany. (*Ingots and forgings.*)

Stahlwerke Bochum A.G., Bochum, Germany. (*Castings, forgings, rolled materials and plates.*)

**El Ferrol**

Aceros del Zarzo S.A. (Adeza) Cabanas Puentedeume (La Coruna), Spain. (*Ingots and small castings.*)

Astilleros y Talleres del Noroeste S.A., El Ferrol del Caudillo, Spain. (*Small forgings.*)

Empresa Nacional Bazan, El Ferrol del Caudillo, Spain. (*Castings*).

**Emden**

Sande, Giesserei, Sande-Oldenburg, Germany. (*Castings.*)

**Fremantle**

Broken Hill Proprietary Co., Ltd., Rolling Mill at Kwinana, W. Australia. (*Small bars and sections.*)

Hadfields (W.A.) 1934 Ltd., Perth, W. Australia. (*Castings.*)

**Gdansk**

Huta Z.M.G.S., Elblag, Poland. (*Castings.*)

Zaklady Metalurgiczne Poznan, "Pomet", Poznan ul Krancowa 15, Poland. (*Castings.*)

**Genoa**

A.S.S.A. Acciaierie di Susa Società Anonima, Turin, Italy. *Head Office:* Turin. *Works:* Susa. (*Castings.*)

Ansaldo S.p.A., Stabilimento Fonderia di Ghisa e Metalli, Genova-Pegli, Italy. (*Forgings.*)

Bolzaneto, Acciaiera de Ferriero di, Genoa, Italy. *Works:* Genoa-Bolzaneto. (*Plates, sections and bars.*)

Cantieri del Tirreno, S.p.A., Riva Trigoso, Genoa, Italy. (*Small forgings.*)

Fabrica Italiana Tubi, Società per Azioni, Sestri-Levante, Italy. (*Ingots, billets and weldless rolled and drawn tubes.*)

FIAT, Società per Azioni, Sezione Ferriere Piemontesi, Turin, Italy. (*Ingots, plates, sections; also seamless and welded tubes.*)

FIAT, Società per Azioni, Sezione Industrie Metallurgiche Acciaierie, Turin, Italy. (*Castings.*)

Fonderia Acciaieria Giovanni Mandelli, Turin, Italy. (*Small castings.*)

"ITALSIDER" Alti Forni e Acciaierie Riunite Ilva e Cornigliano S.p.A. *Head Office:* Via Corsica 4, Genoa, Italy.

S.I.A.C., Genoa. (*Ingots, forgings, plates and castings.*)

Stabilimento Oscar Sinigaglia, Genova-Cornigliano. (*Ingots, slabs and plates.*)

Nazionale "Cogne", S.p.A. *Head Office:* Turin, Italy. *Works:* Aosta. (*Ingots, forgings, plates, sections and bars.*)

**Gijon**

Aceros de Galicia, Vigo, Spain. (*Castings.*)

Duro-Felguera, Sociedad Metalúrgica, La Felguera, Asturias, Spain. (*Ingots, billets, castings, plates and sections.*)

**Gijon**—*continued*

Empresa Nacional Siderurgica, S.A. (ENSIDESA), Avilés, Spain. (*Ingots, slabs and billets for re-rolling, plates and sections.*)

Fabrica de Mieres, Mieres, Asturias, N. Spain. (*Sections, bars and plates up to* 15 *mm. in thickness.*)

"Santa Barbara", Sociedad Industrial Asturiana, Fabricas de Moreda y Gijon, Gijon, Spain. (*Castings and rivet bars.*)

Trubia, Fábrica Nacional de, Trubia Asturias, Spain. (*Castings and forgings.*)

**Gothenburg**

Björneborgs Jernverks Aktiebolag, Björneborg, Sweden. (*Ingots and forgings.*)

Bofors Aktiebolaget, Bofors, Sweden. (*Ingots, forgings, castings and rolled bars.*)

Klafreströms Bruk, A/B, Klavreström, Sweden. (*Small castings.*)

Lesjöfors Aktiebolag, Lesjöfors, Sweden. (*Ingots and bars.*)

Motala Verkstad, A/B, Motala Verkstad, Sweden. (*Ingots, forgings, castings, sections and bars.*)

Stridsberg & Biorck, A.B., Trollhattan, Sweden. (*Castings.*)

Svenska Kullagerfabriken A/B, Hellefors Jernverk, Hällefors, Sweden. (*Ingots and bars.*)

Uddeholms Aktiebolag, Uddeholm, Sweden.

*Works at* Degerfors. (*Ingots, plates, sections and bars.*)

*Works at* Hagfors. (*Castings.*)

*Works at* Nykroppa. (*Ingots.*)

*Works at* Storfors. (*Seamless tubes.*)

**Halifax, N.S.**

Dominion Steel & Coal Corporation Ltd.

Sydney Works, Sydney, N.S. (*Ingots, billets and sections.*)

Trenton Works, Trenton, N.S. (*Forgings.*)

Maritime Steel and Foundries, Ltd., New Glasgow, N.S. (*Small castings.*)

**Hamburg**

Ellerbrock, Hans, Stahlgiesserei und Maschinenfabrik, Hamburg, Germany. (*Castings.*)

**Hanover**

Eisen-und Stahlwerk Pleissner G.m.b.H., Herzberg/Harz, Germany. (*Castings.*)

Friedrich-Carl-Hutte G.m.b.H., Delligsen uber Alfeld/Heine, Germany. (*Castings.*)

Huttenwerk Salzgitter A.G., Salzgitter-Drütte, Germany. (*Ingots, plates, bars and sections.*)

Ilseder Hütte A.G., Peine, Germany. (*Ingots, billets, sections and bars.*)

**Hanover**—*continued*

Klöckner - Werke A.G. Georgsmarienwerke, Osnabrück, Germany. (*Ingots, bars, forgings and castings.*)

Lindener Eisen-und Stahlwerke G.m.b.H., Hannover-Linden, Germany. (*Ingots and castings.*)

MIAG (Mühlenbau und Industrie G.m.b.H.), Braunschweig, Germany. (*Castings.*)

Sollinger Hütte G.m.b.H., Uslar/Solling, Germany. (*Castings.*)

Tweer, Reinhard, G.m.b.H., Brackwede/Westf., Germany, *Works:* Kracks near Bielefeld. (*Castings.*)

**Helsingfors**

Ahlström, A., Oy, Karhulan Tehtaat, Karhula Bruk, Karhula, Finland. (*Castings.*)

Stenberg, Oy John, A.B., Helsingfors, Finland. (*Small castings.*)

Vuoksenniska Oy, Aktiebolag, Imatra Iron Works, Imatra, Finland. (*Ingots, slabs, blooms and billets, bars and sections.*)

**Istanbul**

Makine ve Kimya Endustri, Celik Fabrikasi, Kirikkale, Turkey. (*Ingots, forgings, rolled sections and bars.*)

Turkiye Demir ve Celik Isletmeleri, Karabuk, Turkey. (*Ingots, plates, rolled sections and bars.*)

**Katowice**

Huta 1-Go Maja, Gliwice, Poland. (*Forgings.*)

Huta Baildon, Katowice, Poland. (*Ingots, forgings and bars.*)

Huta Batory, Chorzow-Batory, Poland. (*Forgings, plates and tubes.*)

Huta Bieruta, Czestochowa, Poland. (*Seamless tubes.*)

Huta Bobreck, Bytom, Poland. (*Ingots, slabs and blooms.*)

Huta im M. Buczka, Sosnowiec, Poland. (*Seamless tubes.*)

Huta Dzierzynskiego, Dabrowa Gornicza, Poland. (*Billets, sections and bars.*)

Huta Florian, Swietochlowice, Poland. (*Angles and bars.*)

Huta Jednosc, Siemianowice Slaskie, Poland. (*Ingots and seamless tubes.*)

Huta Kosciuszko, Chorzow, Poland. (*Billets, blooms, sections and rivet bars.*)

Huta Labedy, Labedy, Poland. (*Flats and sections.*)

Huta Lenina, Krakow, Poland. (*Ingots, slabs, plates up to* 12 *mm.*)

Huta Malapanew, Ozimek k/Opola, Poland. (*Castings.*)

Huta Nowotki, Ostrowiec Swietokrzyski, Poland. (*Sections.*)

Huta Pokoj, Ruda Slaska, Poland. (*Plates and sections.*)

Huta Stalowa Wola, Stalowa Wola, Poland. (*Castings, forgings, plates and sections.*)

**Katowice**—*continued*

Huta Zawiercie, Zawiercie, Poland. (*Flats and bars.*)

Zaklady Budowy Przewodow i Armatury, Kielce, Poland. (*Castings.*)

Zaklady Urzadzen Technicznych "Zgoda", Swietochlowice, Poland. (*Forgings.*)

**Kiel**

Nordische Stahlwerke, Bach & Co., Neumünster, Germany. (*Castings.*)

**Kobe**

Aichi Steel Works Ltd.
- Chita Plant, Aichi Prefecture, Japan. (*Ingots and forgings.*)
- Kariya Plant, Aichi Prefecture, Japan. (*Ingots and forgings.*)

Amagasaki Iron & Steel Mfg., Co., Ltd., Steel Plant, Amagasaki, Japan. (*Ingots, plates, sections and bars.*)

Chubu Steel Plate Co., Ltd., Nakagawa Works, Nagoya, Japan. (*Ingots and plates.*)

Daido Steel Co., Ltd.
- Chita Works, Aichi Prefecture, Japan. (*Ingots, billets and bars.*)
- Hoshizaki Works, Nagoya, Japan. (*Ingots and bars.*)
- Tsukiji Works, Nagoya, Japan. (*Ingots, forgings and castings.*)

Fuji Iron & Steel Co., Ltd., Hirohata Works, Hirohata, Himeji City, Japan. (*Ingots, billets, plates and sections.*)

Fujinagata Shipbuilding & Engineering Co., Ltd., Osaka, Japan. (*Castings and forgings.*)

Go Iron Works, Ltd., Tarui Works, Tarui, Japan. (*Small castings.*)

Hitachi Metal Industries Ltd., Yasugi Works, Yasugi, Japan. (*Ingots and bars.*)

Hitachi Shipbuilding & Engineering Co., Ltd.
- Chikko Shipyard, Osaka, Japan. (*Castings and forgings.*)
- Innoshima Shipyard, Innoshima, Japan. (*Forgings and small castings.*)

Howa Machinery, Ltd., Inazawa Plant, Aichi Prefecture, Japan. (*Castings.*)

Ishikawajima-Harima Heavy Industries Co., Ltd., Aioi Works, Aioi, Japan. (*Castings and forgings.*)

Izuo Chukosho Co., Ltd., Osaka, Japan. (*Castings.*)

Kansai Steel Corp., Sakai, Japan. (*Ingots, bars and flat bars.*)

Kansai Tekko Co., Ltd., Amagasaki, Japan. (*Small forgings.*)

Kawasaki Dockyard Co., Ltd., Kobe, Japan. (*Castings and small forgings.*)

Kawasaki Rolling Stock Mfg. Co., Ltd., Kobe, Japan. (*Castings.*)

Kawasaki Steel Corporation.
- Chita Works, Handa City, Japan. (*Ingots.*)
- Fukiai Works, Kobe, Japan. (*Ingots, blooms, sections and plates.*)

**Kobe**—*continued*
- Hyogo Works, Kobe, Japan. (*Castings and forgings.*)
- Nishinomiya Works, Nishinomiya, Japan. (*Ingots and plates.*)

Kinka Kikai Co., Ltd., Gifu, Japan. (*Castings.*)

Kobe Steel Works, Ltd., Kobe, Japan. (*Ingots, blooms, billets, bars and castings.*)

Kobe Steel Works, Ltd., Takasago Plant, Takasago, Japan. (*Ingots, forgings and castings.*)

Kokko Steel Works, Ltd., Osaka, Japan. (*Angles, bars and castings.*)

Kokoku Chuko-sho K.K., Osaka, Japan. (*Castings.*)

Komatsu Manufacturing Co., Ltd.
- Komatsu, Japan. (*Castings.*)
- Osaka Plant, Hirakata, Osaka Prefecture, Japan. (*Castings.*)

Kubota Iron & Machinery Works, Ltd., Hirakata Plant, Hirakata, Osaka, Japan. (*Castings.*)

Kureha Seiko Co., Ltd., No. 1, 5-Chome Takeshima-Cho, Nishiyodogawa-Ku, Osaka, Japan. (*Castings.*)

Kurimoto Iron Works Ltd., Kagaya Works, Osaka, Japan. (*Castings.*)

Maekawa Electric Steel Castings Co., Osaka, Japan. (*Castings.*)

Maizuru Shipbuilding & Eng. Co., Ltd., Maizuru Shipyard, Maizuru, Japan. (*Small forgings and castings.*)

Mitsuboshi Iron Works Co., Ltd., Osaka, Japan. (*Small forgings.*)

Mitsui Shipbuilding & Engineering Co., Ltd., Tamano, Japan. (*Ingots, forgings and castings.*)

Mitsumoto Valve Manufacturing Co., Ltd., Domyoji, Osaka, Japan. (*Small forgings and small castings.*)

Nakayama Steel Works, Osaka, Japan. (*Ingots, forgings, and plates up to 25 mm. in thickness.*)

Nippon Sharyo Seizo Kaisha Ltd., Nagoya, Japan. (*Castings.*)

Nippon Steel Foundry Co., Ltd., Osaka, Japan. (*Castings.*)

Nippon Tanko Co., Ltd., Amagasaki, Japan. (*Small forgings.*)

Nisshin Seiko Co., Ltd., Shikama Plant, Himeji, Japan. (*Rolled bars.*)

Ohtani Heavy Industrial Co., Ltd.
- Amagasaki Plant, Amagasaki, Japan. (*Plates up to 12,5 mm. in thickness.*)

Okamoto Iron Works Co., Kobe, Japan. (*Forgings.*)

Onomichi Anchor Manufacturing Co., Ltd., Onomichi, Japan. (*Castings.*)

Osaka Chain & Machinery Manufacturing Co., Ltd., Kaizuka Works, Osaka, Japan. (*Small castings.*)

Osaka Steel Casting Co., Ltd., Osaka, Japan. (*Small castings.*)

Otani Steel Works Ltd., Osaka, Japan. (*Ingots and plates.*)

Sanyo Special Steel Co., Ltd., Himeji, Japan. (*Ingots and forgings.*)

**Kobe**—*continued*

Seo High Pressure Industry Co., Ltd., Osaka, Japan. (*Small forgings.*)

Shin Mitsubishi Heavy Industries Ltd.,
- Kobe Shipyard & Engine Works, Kobe, Japan. (*Ingots and small forgings.*)
- Kobe Shipyard, Takasago Factory, Takasago, Japan (*Forgings.*)
- Mihara Engineering Works, Mihara, Japan. (*Castings and forgings.*)

Sumitomo Electric Industries, Ltd., Itami Works, Itami, Hyogo Prefecture, Japan. (*Ingots and small bars.*)

Sumitomo Machinery Co., Ltd., Niihama, Japan. (*Castings.*)

Sumitomo Metal Industries, Ltd.
- Osaka Steel Works, Osaka, Japan. (*Castings, forgings and bars.*)
- Steel Tube Works, Amagasaki, Japan. (*Ingots, forgings, small bars, sections and weldless tubes.*)
- Wakayama Steel Works, Wakayama, Japan. (*Small ingots, plates, seamless tubes and electric resistance welded tubes.*)

Takada Steel Works, Ltd., Takada City, Nara Prefecture, Japan. (*Castings.*)

Teikoku Kokan Seizosho K.K., Osaka, Japan. (*Seamless tubes.*)

Toho Seiko Kabushiki Kaisha, Nagoya, Japan. (*Castings.*)

Topy Industries Ltd., Toyohashi Works, Toyohashi, Japan. (*Ingots, sections and flat bars.*)

Toyo Kikai-Kinzoku Co., Ltd., Tsuchiyama Plant, Akashi, Japan. (*Castings.*)

Tsukamoto Sogyo Co., Ltd., Osaka Works, Osaka, Japan. (*Castings.*)

Washino Machine Co., Ltd., Imamura Plant, Aichi Prefecture, Japan. (*Castings.*)

Yamato Steel Works, Ltd., Osaka, Japan. (*Ingots, sections and plates.*)

Yawata Iron & Steel Co., Ltd., Sakai Works, Sakai Osaka, Japan. (*Rolling mills for sections.*)

Yonago Steel Works, Ltd., Yonago, Japan. (*Castings.*)

**La Spezia**

Faggian, Acciaierie Elettriche Pio, Soc. per Azioni, La Spezia, Italy. (*Small castings.*)

**Leghorn**

"ITALSIDER" Alti Forni e Acciaierie Ruinite Ilva e Cornigliano S.p.A., Stabilimento di Portovecchio di Piombino, Italy. (*Ingots, blooms, sections and bars.*)

**Lisbon**

"COMETNA" Companhia Metalurgica Nacional, S.A.R.L., Amadora, Portugal. (*Castings.*)

Metalurgica Duarte Ferreira S.a.r.l., Tramagal, Portugal. (*Castings.*)

União Fabril, Companhia, Barreiro, Portugal. (*Castings.*)

**Los Angeles**

Bethlehem Steel Co., Los Angeles 54, Cal., U.S.A. (*Round bars.*)

Kaiser Steel Corporation, Fontana, Cal., U.S.A. (*Ingots and plates.*)

Los Angeles Steel Casting Co., Los Angeles, Cal., U.S.A. (*Castings.*)

United States Steel Corporation.
- Torrance Works, Torrance, Calif., U.S.A. (*Round bars and sections.*)
- Geneva Works, Provo, Utah, U.S.A. (*Plates.*)

**Malmö**

Anderson, Aktiebolaget Abjörn, Svedala, near Malmö, Sweden. (*Castings.*)

Kockums Jernverk, Kallinge, Sweden. (*Castings.*)

**Mannheim**

Dingler, Karcher & Cie., G.m.b.H., Saarländisches Stahlwerk, Worms/Rhein. (*Castings.*)

Schütze A.G., Ludwigshafen-Oggersheim, Germany. (*Electric steel castings.*)

Stahlwerk Mannheim A.G., Mannheim-Rheinau. (*Ingots, forgings and castings.*)

**Marseilles**

Aciéries du Furan, St. Etienne (Loire), France. (*Electric steel castings.*)

Aubert et Duval, Anciens Ets., Aciéries des Ancizes, Puy de Dôme. (*Ingots, rolled bars and forgings.*)

Compagnie des Ateliers et Forges de la Loire :
- Usines de l'Ondaine, Firmigny (Loire), France. (*Ingots, billets, blooms, bars, castings and forgings.*)
- Usines de St. Chamond (Loire), France. (*Forgings and plates.*)
- Usines de l'Ondaine, Unieux (Loire), France. (*Forgings.*)
- Usines de St. Etienne, St. Etienne (Loire), France. (*Plates.*)

Feurs, Fonderies & Acieries Electriques de, Feurs, Loire, France. (*Small castings.*)

d'Imphy, Société Metallurgique, Usine de Pamiers (Ariège), France. (*Castings and forgings.*)

Marrel Frères, Société Anonyme des Etablissements, Usine des Etaings, near Rive-de-Ciers (Loire), France. (*Ingots, forgings, plates and bars.*)

Méridionales, Fonderies, Marseilles, France. (*Castings.*)

Provence, Fonderies et Aciéries de, Marseilles, France. (*Castings.*)

Saut-du-Tarn, Société Anonyme des Forges et Aciéries du, Saint-Juéry (Tarn), France. (*Castings.*)

Tamaris, Société des Ateliers et Fonderies des, Tamaris (Gard), France. (*Castings.*)

**Marseilles**—*continued*

Teil, Fonderies et Aciéries du, Usine du Frayol, Le Teil (Ardèche), France. (*Small castings.*)

Temple, Aciéries du, Saint-Michel de Maurienne, (Savoie) France. (*Rolled and forged bars and billets.*)

d'Ugine, Aciéries Electriques, Ugine (Savoie), France. (*Ingots, billets, bars, sections, castings and forgings.*)

**Melbourne**

Davies & Baird Pty., Ltd., 227 Brunswick Road, Brunswick, Melbourne 10, Australia. (*Castings.*)

K.M. Steel Products Pty., Ltd., Brooklyn, Melbourne. (*Ingots.*)

Steel Company of Australia, Pty., Ltd., Coburg, Melbourne. (*Castings.*)

Vickers, Ruwolt, Pty., Ltd., Richmond, Melbourne. (*Castings.*)

**Metz** (*Saarbrücken District*)

de Wendel et Cie., S/A, Hayange, Moselle, France.
- Usine de Fenderie. (*Plates.*)
- Usine de St. Jaques. (*Sections.*)

Lorraine-Escaut S.A.
- Usine de Longwy, Section Mont-St.-Martin, Mont-St.-Martin (Meurthe et Moselle). (*Sections and plates.*)
- Usine de Longwy, Section Senelle, Longwy-Bas (Meurthe et Moselle.) (*Ingots, blooms, bars and sections.*)
- Usine de Thionville, Thionville (Moselle). (*Forgings.*)

Pompey, Société des Aciéries de, Usine de Pompey, Meurthe et Moselle, France. (*Ingots, blooms, billets, plates, angles and round bars.*)

S.A.F.E., Société des Aciers Fins de l'Est, Hagondange, Moselle, France. (*Ingots, blooms, billets, bars, plates and sheets.*)

Société Lorraine de Laminage Continu, Sollac, B.P.13, Serémange, Moselle, France. (*Ingots, slabs and plates.*)

Société Mosellane de Siderurgie, Hagondange (Moselle), France. (*Blooms, billets, bars and sections.*)

Union Sidérurgique Lorraine, SIDELOR, Usine d'Homécourt, Meurthe et Moselle, France. (*Ingots, blooms, billets and plates.*)
- Usine de Micheville, Villerupt, Meurthe et Moselle, France. (*Ingots, blooms, billets, bars and sections.*)
- Usine de Rombas, Moselle, France. (*Ingots, blooms, billets, bars and sections.*)

**Milan**

Amsco Italiana S.p.A., Milan. (*Small castings.*)

Breda Fucine, S.p.A., Sesto San Giovanni, Milan. (*Castings and forgings.*)

Breda Siderurgica, S.p.A., Sesto San Giovanni, Milan. (*Ingots and sections.*)

**Milan**—*continued*

Brescia, Acciaieria e Turbificio di, S.p.A., Brescia. (*Ingots, sections and bars, castings, weldless or water gas welded tubular materials.*)

Caleotto, Acciaieria e Ferriera del, S.p.A., Lecco. (*Ingots, castings, bars, small sections and small forgings.*)

Cantieri Navali Riuniti. *Head Office:* Genoa. *Works:* Cantieri Navale ed Officine Meccaniche di Ancona. (*Small castings.*)

Ceretti, Pietro Maria, S.p.A., Ferriera dell' Ossola-Villadossola. (*Castings.*)

Dalmine, S.p.A. *Head Office:* Milan.
- Dalmine Costa Volpino, Bergamo. (*Seamless tubes*).
- Dalmine Works, Bergamo. (*Ingots and seamless tubes.*)

Falck, Acciaierie e Ferriere Lombarde. *Head Office & Works:* Milan. (*Weldless rolled or drawn tubes.*)
- Concordia Works, Sesto San Giovanni, Milan. (*Rolling mill for plates.*)
- Unione Works, Sesto San Giovanni, Milan. (*Ingots, sections, bars, forgings and castings.*)

"ITALSIDER" Alti Forni e Acciaierie Riunite Ilva e Cornigliano S.p.A., Stabilimento di Lovere. (*Sections, bars, castings and forgings.*)

Luigi Giudici, Fonderie e Smalterie Rescaldina, Milan. (*Small castings.*)

Metallurgica Marcora, Busto Arsizio (Varese). (*Weldless rolled and drawn tubes.*)

Pracchi, Fonderie Elettriche O., S.p.A., Milan. (*Small castings.*)

Sesto San Giovanni, S.p.A., Acciaierie Elettriche di, S.p.A., Sesto San Giovanni, Milan. (*Castings.*)

S.I.S.M.A.—Società Industrie Siderurgiche Meccaniche & Affini, Villadossola (Novara). (*Rolled bars and rivets.*)

Società Metallurgica Vittorio Cobianchi S.p.A.
*Head Office:* Milan.
*Works:* Omegna (Novara.) (*Castings.*)

Stramezzi, P., & C., Acciaieria e Ferriera di Crema, Crema. (*Ingots, bars, small sections and rivets.*)

Tassara S.A., Carlo, and Metalcam S.p.A., Breno, Brescia, Italy. (*Ingots, bars and small forgings.*)

Tosi, Franco, S.p.A., Legnano. (*Forgings and castings.*)

Villa, Giovanni, S.p.A., Officine Meccaniche-Fucinati-Stampati, Milan. (*Forgings.*)

**Mobile, Ala.**

Kilby Steel Co., Furnace Division, Anniston, Ala., U.S.A. (*Ingots.*)

Republic Steel Corporation, Alabama City, Ala., U.S.A.

Tennessee Coal & Iron Division, United States Steel Corporation, Birmingham, Ala., U.S.A. *Works:* Ensley, Ala.; *Rolling mills and forgings:* Bessemer and Fairfield, Ala.

**Montreal**

Canadian Steel Foundries, Ltd., Longue Pointe, Montreal, P.Q., Canada. (*Castings.*)

Canadian Unitcast-Steel, Ltd., Sherbrooke, P.Q., Canada. (*Castings.*)

Crucible Steel Company of Canada, Ltd., Sorel, P.Q., Canada. (*Castings.*)

Dominion Steel & Coal Corporation Ltd., Montreal Works, 5870, St. Patrick Street, Montreal, P.Q., Canada. (*Angles, bars and rivets.*)

Lynn Macleod Metallurgy, Ltd., Thetford Mines, P.Q., Canada. (*Castings.*)

Manitoba Rolling Mill Co., Ltd., Selkirk, Manitoba, Canada. (*Billets, bars and sections.*)

Sorel Steel Foundries, Ltd., Sorel, P.Q., Canada. (*Castings.*)

Steel Company of Canada, Hamilton, Ontario, Canada. *Works :* Montreal. (*Bars and angles, plates and billets.*)

**Nagasaki**

Mitsubishi Shipbuilding and Engineering Co., Ltd., Nagasaki Works, Nagasaki, Japan. (*Castings and small forgings.*)

Mitsubishi Steel Manufacturing Co., Ltd., Nagasaki Works, Nagasaki, Japan. (*Ingots, blooms, plates, forgings and castings.*)

Sasebo Heavy Industries Co., Ltd., Sasebo, Japan. (*Castings and forgings.*)

**Nantes**

d'Hennebont, Forges, Hennebont, Morbihan, France. (*Castings.*)

Marine Nationale Indret, Etablissements de la, Loire-Atlantique, France. (*Castings.*)

Sambre et Meuse, Société Anonyme des Usines & Aciéries de, Usines de Saint Brieuc, Cotes-du-Nord. (*Small castings.*)

**Naples**

"ITALSIDER" Alti Forni e Acciaierie Riunite Ilva e Cornigliano S.p.A.
Stabilimento di Bagnoli. (*Ingots, sections and bars.*)
Stabilimento di Taranto. (*Rolling mill for plates.*)

MECFOND-Officine Meccaniche e Fonderie Napoletane, Naples, Italy. (*Castings.*)

Meridionali, Acciaierie e Tubificio, S.p.A., Bari, Italy. (*Castings and weldless rolled or drawn tubes.*)

"Terni" Società per l'Industria e l'Elettricha.
*Works :* Terni. (*Ingots, forgings, castings and plates.*)

**Newcastle, N.S.W.**

Broken Hill Proprietary Co., Ltd., Iron and Steel Works, Newcastle, N.S.W. (*Ingots, billets, plates, sections, strip and castings.*)

Commonwealth Steel Co., Ltd., Waratah, Newcastle, N.S.W. (*Castings and forgings.*)

**Newport News, Va.**

Newport News Shipbuilding & Dry Dock Co., Newport News, Va., U.S.A. (*Castings and forgings.*)

**Odense**

Varde Staalvaerk, Varde, Denmark. (*Ingots and castings.*)

**Oslo**

Christiania Spigerverk, Oslo. (*Ingots and bars, also rivet bars.*)

Drammens Jernstoberi & Mek-Verksted, A/S, Drammen. (*Small castings.*)

Norsk Jernverk, A/S, Mo-i-Rana. (*Electric steel ingots, billets, sections and bars.*)

Raufoss Ammunisjonsfabrikker, Raufoss. (*Castings.*)

Strömmens Verksted, A/S, near Oslo. (*Castings.*)

**Paris**

d'Auxonne, Aciéries & Fonderies, Auxonne (Côté d'Or), France. (*Small castings.*)

"Acieroy" Aciéries et Fonderies du Doubs, Société Anonyme, Sainte-Suzanne, near Montbéliard (Doubs), France. (*Small electric steel castings.*)

Creusot, Société des Forges et Ateliers du (S.F.A.C.), Usines Schneider, Le Creusot, France. (*Ingots, forgings, castings, plates and sections.*)

Ferry-Captain & Cie, Société, Bussy, près Joinville (Haute Marne), France. (*Electric steel castings.*)

Gennevilliers, Aciéries de, Gennevilliers, (Seine), France. (*Castings.*)

Guerigny, Forges Nationales de la Chaussade à (Nièvre), France. (*Ingots, bars, forgings and castings.*)

Geugnon, Forges de, Geugnon, (S. & L.), France. (*Rolling mill for plates.*)

Hachette & Driout, S.A., des Anciens Etablissements St. Dizier, (Haute Marne), France. (*Castings.*)

d'Imphy, Société Metallurgique, Aciéries d'Imphy (Nièvre), France. (*Ingots, forgings, bars and sections.*)

Maitre & Cie, Ets, Colombier-Fontanie (Doubs), France. (*Small castings.*)

Montluçon, Commentry, Societé des Forges et Ateliers de, Usines St. Jacques, Montluçon (Allier), France. (*Castings, ingots, forgings, sheets and sections.*)

Paris-Seine, Fonderies et Aciéries, Usine de la Folie, Avenue de Bobigny, Noisy-le-Sec. (Seine), France. (*Castings.*)

**Philadelphia, Pa.**

Atlantic Steel Castings Co., The, Chester, Pa., U.S.A. (*Castings.*)

Bethlehem Steel Co., Bethlehem, Pa., U.S.A. (*Ingots, forgings, bars and sections.*)
Lebanon, Pa., U.S.A. (*Rolling mills for bars.*)
Steelton, Pa., U.S.A. (*Castings.*)

Birdsboro Corporation, Birdsboro, Pa., U.S.A. (*Castings.*)

Dodge Steel Company, Tacony, Philadelphia, Pa., U.S.A. (*Small castings.*)

Donegal Steel Foundry Company, 601, East Market Street, Marietta, Pa., U.S.A. (*Castings.*)

Empire Steel Castings Inc., Reading Pa., U.S.A. (*Castings.*)

**Philadelphia, Pa.**—*continued*

Lebanon Steel Foundry, Lebanon, Pa., U.S.A. (*Small castings.*)

Lukens Steel Company, Coatesville, Pa., U.S.A. (*Plates.*)

Midvale-Heppenstall Company, Nicetown, Philadelphia, Pa., U.S.A. (*Forgings.*)

Penn Steel Castings Co., Chester, Pa., U.S.A. (*Castings.*)

Pennsylvania Steel Foundry and Machine Company, Hamburg, Pa., U.S.A. (*Castings.*)

Pennsylvania Forge, Division of Chemetron Corporation, Tacony, Philadelphia 35, Pa., U.S.A. (*Forgings.*)

Phoenix Steel Corporation.

*Works:* Claymont, Delaware, U.S.A. (*Plates.*)

*Works:* Structural Division, Phoenixville, Pa., U.S.A. (*Sections, bars and rotary forged seamless tubes.*)

Quaker Alloy Casting Co., Myerstown, Pa., U.S.A. (*Small castings.*)

Standard Steel Division of Baldwin-Lima-Hamilton Corp., Burnham, Mifflin County, Pa., U.S.A. (*Castings and forgings.*)

United States Steel Corporation, Fairless Works, Morrisville, Pa., U.S.A. (*Thin plates, bars and sections.*)

Wood, Alan, Steel Company, Conshohocken, Pa., U.S.A. (*Blooms, billets and plates.*)

**Piraeus**

Nicolacopoulos G., & Co., Athens, Greece, Steelworks at Eleusis. (*Castings.*)

Viomichania Chalyvon Ltd., Athens Greece. (*Castings.*)

**Pittsburgh, Pa.**

Alco Products, Inc., Latrobe, Pa., U.S.A. (*Ingots and forgings.*)

Bethlehem Steel Co., Johnstown Plant, Johnstown, Pa., U.S.A.

Byers Company A.M. Admin. Office:- Clark Building, Pittsburgh 22, Pa., U.S.A.

Economy Pa., (*Plates, bars and ingots for forging.*)

Crucible Steel Company of America, 4 Gateway Center, P.O. Box 88, Pittsburgh 30, Pa., U.S.A.

Midland Plant, Midland, Pa. (*Ingots, slabs, billets, universal mill plates, hot rolled and cold drawn bars.*)

Jones & Laughlin Steel Corporation, Pittsburgh, Pa., U.S.A.

National Malleable & Steel Castings Co., Sharon, Pa., U.S.A. (*Castings.*)

Pittsburgh Steel Company, Pittsburgh 30, Pa., U.S.A.

*Works:* Monessen, Pa. (*Ingots, billets and slabs.*)

*Works:* Allenport, Pa. (*Rolling mills.*)

Republic Steel Corporation, Cleveland, O., U.S.A., Youngstown District, Youngstown, O., U.S.A.

**Pittsburg, Pa.**—*continued*

United States Steel Corporation, Pittsburgh, Pa., U.S.A.

Clairton Works, Clairton, Pa. (*Ingots, blooms, bars and sections.*)

Duquesne Works, Duquesne, Pa. (*Ingots, billets, blooms and bars.*)

Homestead District Works, Pa., (*including* McKees Rock Works.) (*Ingots, billets, blooms, slabs, plates, sections and forgings.*)

Irvin Works, Dravosburg, Pa. (*Rolling mills for thin plates.*)

McDonald Mills, Youngstown. (*Rolling mills for bars and sections.*)

Ohio Works, Youngstown. (*Ingots, billets and blooms.*)

Youngstown Sheet and Tube Company.

Brier Hill Works, Youngstown, Ohio, U.S.A.

Campbell Works, Campbell, Mahoning Co., Ohio, U.S.A.

(*Ingots and plates up to* 12,5 *mm. in thickness.*)

**Port Kembla**

Australian Iron & Steel Pty., Ltd., Port Kembla, N.S.W. (*Plates, bars, sections and forgings.*)

**Port Said**

Egyptian Iron & Steel Co., S.A.E., Helwan, U.A.R. (*Plates.*)

**Rijeka**

Tvornica Dizalica I Ljevaonica "Vulkan", Rijeka 11, Yugoslavia. (*Castings.*)

Zelezarna Ravne, Ravne na Koroskem, Yugoslavia. (*Castings and forgings.*)

Zeljezara Sisak, Sisak Predgradje, Yugoslavia. (*Seamless tubes.*)

**Rio de Janeiro**

Acos Villares S.A., Sao Caetano do Sul, Sao Paulo, Brazil. (*Castings, forgings, billets and bars.*)

Brasileira de Usinas Metalurgicas, The Companhia, Usina de Neves Sao Goncalo, Estado do Rio de Janeiro, Brazil. (*Ingots, sections and bars.*)

Companhia Siderurgica Nacional, Volta Redonda, Estado do Rio de Janeiro, Brazil. (*Plates and sections.*)

Mineracao Geral do Brazil, Lda., Sao Paulo, Brazil. (*Ingots and weldless tubes.*)

Usinas Siderurgicas de Minas Gerais S.A., Belo Horizonte, Estado de Minas Gerais, Brazil.

*Works:* Ipatinga, Estado de Minas Gerais. (*Ingots, slabs and plates.*)

**Rotterdam**

Bakker N.V., Machinefabriek-Staalgieterij, Ridderkerk, Holland. (*Ingots and castings.*)

Rotterdamsche Droogdok Maatschappij, Rotterdam, Holland. (*Ingots, forgings and small castings.*)

**Rouen**

Société des Aciéries de Pompey, Usines du Manoir à Pitres (Eure), France. (*Castings.*)

Société Métallurgique de Normandie, Mondeville, France. (*Ingots, blooms, billets and bars.*)

**Saarbrücken-Saar**

"ARBED," Aciéries Réunies de Burbach - Eich - Dudelange.

Division de Burbach, Sarrebruck.

Burbach Works. (*Ingots, billets and sections.*)

Hostenbach Works. (*Plates.*)

Dingler, Karcher & Cie., G.m.b.H., Saarbrücken, Saar. (*Castings.*)

Pohlig-Heckel Bleichert, Vereinigte Maschinenfabriken A.G., Abt. Stahlformgiesserei, Werk Heckel, Rohrbach/Saar, Germany. (*Castings.*)

Röchling'sche Eisen-und Stahlwerke G.m.b.H., Völklingen (Saar). (*Castings, ingots, billets, bars and forgings.*)

Société Anonyme des Forges et Aciéries de Dilling, Dillingen, Sarre. (*Ingots and plates.*)

**San Francisco, Cal.**

Enterprise Engine & Foundry Co., South City, Cal., U.S.A. (*Castings.*)

General Metals Corporation, Oakland, Cal., U.S.A. (*Castings.*)

Pacific States Steel Corporation, Union City, Cal., U.S.A. (*Ingots, sections and bars.*)

Pacific Steel Castings Co., Berkeley, Cal., U.S.A. (*Castings.*)

**Santiago**

Pacifico, Compania de Acero del, S.A., Talcahuano, Chile. (*Ingots, plates, bars and sections.*)

**Seattle, Wash.**

Bethlehem Steel Co., Seattle, Wash., U.S.A. (*Sections and bars.*)

Isaacson Iron Works, P.O. Box 3625, Seattle, Wash., U.S.A. (*Ingots.*)

Olympic Steel Works, Seattle, Wash., U.S.A. (*Castings.*)

Washington Iron Works, Seattle, Wash., U.S.A. (*Castings.*)

**Shimonoseki**

Amagasaki Iron & Steel Manufacturing Co., Ltd., Kure Steel Works, Kure, Japan. (*Ingots, castings and small forgings.*)

Hitachi Ltd., Kasado Works, Kudamatsu, Japan. (*Castings and forgings.*)

Hitachi Metal Industries Ltd., Tobata Works, Tobata, Japan. (*Castings.*)

**Shimonoseki**—*continued*

Japan Steel Works Ltd., Hiroshima Works, Hiroshima, Japan. (*Forgings and castings.*)

Kotobuki Kogyo Co., Ltd., Hiro Works, Kure, Japan. (*Castings.*)

Kure Shipbuilding & Engineering Co., Ltd., Kure, Japan. (*Small forgings.*)

Matsuya Kogyo Co., Ltd., Fukuoka, Japan. (*Small forgings.*)

Mitsubishi Shipbuilding & Engineering Co., Ltd., Hiroshima Works, Hiroshima, Japan. (*Ingots, castings and small forgings.*)

Nagasaki Works, Nagasaki, Japan. (*Castings and small forgings.*)

Shimonoseki Works, Shimonoseki, Japan. (*Small forgings.*)

Mitsui Miike Machinery Co., Ltd., Miike Works, Omutashi, Japan. (*Castings.*)

Nisshin Steel Works, Ltd., Kure Works, Kure, Japan. (*Ingots, blooms, billets and strip.*)

Okano Valve Manufacturing Co., Ltd., Moji. *Works:* Yukuhashi, Japan. (*Small castings.*)

Osaka Steel Tube Co., Ltd., Sasebo Works, Sasebo, Japan. (*Seamless tubes.*)

Ozuki Seikosho Ltd., Shimonoseki, Japan. (*Castings.*)

Sumitomo Metal Industries, Ltd., Kokura Steel Works, Kokura, Japan. (*Ingots, billets, bars and sections.*)

Ube Industries, Ltd., Ube Machinery Works, Ube, Japan. (*Ingots, forgings and castings.*)

Yawata Iron and Steel Co., Ltd., Yawata Works, Yawata, Japan.

Tobata Plant. (*Plates.*)

Yawata Plant. (*Plates, sections, ingots and forgings.*)

**Split**

Titovi Zavodi Litostroj, Ljubljana, Yugoslavia. (*Castings.*)

Zelezarna Jesenice, Jesenice, Yugoslavia. (*Plates, bars, sections and small castings.*)

Zeljezara Zenica, Zenica, Yugoslavia. (*Billets, bars, sections and forgings.*)

**Stockholm**

Avesta Jernverks Aktiebolag, Avesta, Sweden. (*Plates, sections and castings; also high pressure air receivers.*)

Boxholms A/B., Boxholm, Sweden. (*Ingots, rolled slabs, blooms, billets, sections and bars.*)

Fagersta Bruks Aktiebolag, Fagersta, Sweden (Bruks-koncernen.)

*Works:* Fagersta. (*Blooms, billets, forgings, rolled bars and electric resistance welded tubes.*)

**Stockholm**—*continued*

*Works:* Forsbacka. (*Blooms, billets, forged and rolled bars.*)

*Works*: Horndal. (*Bars and sections.*)

*Works:* Osterbybruk. (*Castings, forgings and rolling mill for bars.*)

Hallstahammar Aktiebolag, Hallstahammar, Sweden. (*Bars.*)

Hults Bruk A.B., Aby, Sweden. (*Castings.*)

Kanthal, A/B, Hallstahammer, Sweden. (*Ingots, billets, bars and castings.*)

Kohlswa Jernverks Aktiebolag. (*Ingots, forgings and castings.*)

Larssons A/B, P. S., Gjuteri & Aduceringsverk, Eskilduna, Sweden. (*Castings.*)

Nordiska Armaturfabrikerna, A/B, Linköping, Sweden. (*Castings.*)

Norrbottens Järnverk Aktiebolag, Lulea, Sweden. (*Ingots, slabs, blooms and billets, bars and sections.*)

Oxelosunds Jarnverk, Oxelosund, Sweden. (*Ingots, rolled slabs and plates.*)

Ramnas Bruks Aktiebolag, Ramnas, Sweden. (*Rolling mills for bars.*)

SKF, Hofors Bruk, Hofors, Sweden. (*Billets, bars, forgings and thick walled tubes.*)

Sandvikens Jernverks Aktiebolag, Sandviken, Sweden. (*Ingots, forgings, and tubes.*)

Smedjebackens Valsverks Aktiebolag, Smedjebacken, Sweden. (*Sections, castings and ingots for re-rolling.*)

Stål och Maskinaktiebolaget, Upsala, Sweden. (*Ingots.*)

Stora Kopparbergs Bergslags Aktiebolag, Falun, Sweden.

*Works:* Domnarfvet. (*Castings, ingots, sections and plates.*)

*Works:* Söderfors. (*Forgings, bars and sections.*)

Surahammars Bruks Aktiebolag, Surahammar, Sweden. (*Plates, forgings and castings.*)

Svenska Jarnvagsverkstaderna, A/B, Linköping, Sweden. (*Castings.*)

Svenska Kullagerfabriken, Aktiebolaget, Katrineholm, Sweden. (*Castings.*)

Wikmanshytte Bruks A/B, Wikmanshyttan, Sweden. (*Forgings, bars and sections.*)

**Sydney, N.S.W.**

Bradford, Kendall, Ltd., Alexandria, Sydney, N.S.W. (*Castings.*)

Hadfields Steel Works, Ltd., Alexandria, Sydney, N.S.W. (*Castings and forgings.*)

Industrial Steels, Ltd., Lidcombe, Sydney, N.S.W. (*Castings.*)

**Tampico**

Altos Hornos de Mexico, S.A., (A.H.M.S.A.), Monclova, Coah., Mexico. (*Plates*).

**Toronto, Ontario**

Algoma Steel Corporation, Ltd., Sault St. Marie, Ontario, Canada. (*Billets, bars, angles and plates.*)

Atlas Steels Company, Welland, Ontario, Canada. (*Ingots and bars.*)

Burlington Steel Company, Division of States Steel Industries, Ltd., Hamilton, Ontario, Canada. (*Small sections and bars.*)

Canada Foundries & Forgings, Ltd., Welland, Ontario, Canada. (*Forgings.*)

Dominion Foundries & Steel, Ltd., Hamilton, Ontario, Canada. (*Ingots, plates and castings.*)

Interprovincial Steel and Pipe Corporation Ltd., Regina, Saskatchewan, Canada. (*Plates.*)

Steel Company of Canada, Hamilton, Ontario, Canada. (*Bars and angles, plates and billets.*)

Welland Electric Steel Foundry, Ltd., Welland, Ontario, Canada. (*Small castings.*)

**Trieste**

F.A.S.E.F., S.p.A., Fonderie Acciaio Scabar e Figli, Porto Industriale, Trieste, Italy. (*Small castings.*)

Bertoli fu Rudolfo, S.p.A., Officine Fratelli, Udine, Italy. (*Castings, forgings, bars and sections.*)

Crane-Orion S.p.A., Porto Industriale, Trieste, Italy. (*Forgings and castings.*)

Gorizia, S.A. Fonderie Officine di, Gorizia, Italy. (*Small castings.*)

S.A.F.A.U. Ferriere Acciaierie di Udine, Udine, Italy. (*Ingots, forgings, blooms, bars and sections.*)

**Valencia**

"ELCANO", Empresa Nacional, Factoria de Manises, Valencia, Spain. (*Castings and forgings.*)

Vizcaya, Altos Hornos de, S.A., Fabrica de Sagunto, Sagunto, Spain. (*Ingots, plates, bars and sections.*)

**Valenciennes**

Blanc-Misseron, Société Française des Aciéries de, Quievrechain (Nord), France. (*Ingots and castings.*)

Chiers, Société des Hauts-Fourneaux de la, Forges de Vireux Molhain, Vireux, Ardennes, France. (*Plates, bars and sections.*)

Compagnie des Ateliers et Forges de la Loire, Usine des dunes, Malo les Bains (Nord), France. (*Ingots, billets, blooms, bars and forgings.*)

Constructions Electriques de Jeumont, Forges et Ateliers de, Jeumont (Nord), France. (*Castings.*)

Dembiermont & Cie., Maurice, Hautmont (Nord), France. (*Forgings.*)

Fives-Lille-Cail, Société de.

Usine de Fives, Lille (Nord), France. (*Forgings.*)

Usine de Denain, Denain (Nord), France. (*Castings, ingots, forgings, blooms, bars and sheets.*)

**Valenciennes**—*continued*

Haine - St. - Pierre et Lesquin, Aciéries de, Société Anonyme, Lesquin-lez-Lille (Nord), France. (*Castings.*)

d'Hirson S.A., Aciéries, Hirson, Aisne, France. (*Castings.*)

Laminoirs, Société Anonyme des, Hauts-Fourneaux, Forges et Fonderies, de la Providence, Hautmont (Nord), France. (*Ingots, plates and sections.*)

Lorraine-Escaut S.A.

Département Tubes, Usine d'Anzin, Anzin (Nord), France. (*Ingots and weldless rolled or drawn tubes.*)

Usine de Sedan, Sedan (Ardennes). (*Plates.*)

Marquise, Usines Métallurgiques de, Rinxent, Pas-de-Calais. (*Castings.*)

Maubeuge, Société Anonyme de la Fabrique de Fer de, Louvroil (Nord). (*Ingots and plates.*)

Meuse, Société Metallurgique de la, Forges et Aciéries de Stenay, Stenay, Meuse. (*Small castings.*)

Paris et d'Outreau, Aciéries de, Société Anonyme, Usine d'Outreau, Pas de Calais. (*Castings.*)

Porter, H. K., (France), Aciéries Division Marpent, Marpent (Nord), France. (*Castings.*)

Sambre et Meuse, Société Anonyme des Usines et Aciéries de, Usines de Feignies, Feignies (Nord). (*Castings.*)

Union Siderurgique du Nord de la France.

Usinor Groupe A.

Usines de Denain, Denain (Nord). (*Ingots, plates, sections and castings.*)

Usinor Groupe B.

Usines de Louvroil-Hautmont, Hautmont (Nord). (*Ingots, bars and sections.*)

Usines de Valenciennes, Valenciennes (Nord). (*Ingots, forgings, blooms, bars and sections.*)

Vallourec, Société, Usine d'Aulnoye, Aulnoye (Nord), France. (*Weldless rolled and drawn tubes.*)

**Vancouver, B.C.**

A.1. Iron & Steel Foundry Ltd., Vancouver, B.C., Canada. (*Small castings.*)

Canadian Sumner Iron Works Ltd., Vancouver, B.C., Canada. (*Small castings.*)

Esco Ltd., Port Coquitlam, B.C., Canada (*Castings.*)

Victoria Machinery Depot Co., Ltd., Victoria, B.C., Canada. (*Castings.*)

Western Canada Steel Ltd., (Vancouver Rolling Mills Ltd.,) Vancouver, B.C., Canada. (*Sections and bars.*)

**Venice (Mestre)**

Bolzano, S.p.A. Acciaierie di, Bolzano. (*Ingots, billets, bars and forgings.*)

Gresele, Acciaierie Valbruna di Ernesto, Vicenza. (*Castings, bars, sections and forgings.*)

"ITALSIDER" Alti Forni e Acciaierie Riunite Ilva e Cornigliano S.p.A., Stabilimento di Marghera. (*Rolling mills for small sections and bars.*)

**Vereeniging**

Dunswart Iron & Steel Works, Ltd., Benoni, South Africa. (*Castings, ingots, billets, and small sections.*)

Scaw Metals, Ltd., Union Junction, Transvaal, S. Africa. (*Rivet bars, small rolled sections and castings.*)

South African Iron & Steel Industrial Corporation, Ltd.

"Iscor" Works, Pretoria, Transvaal, S. Africa. (*Ingots, billets, sections and thin plates up to $\frac{3}{8}$ inch thick.*)

"Iscor" Works, Vanderbijl Park, Transvaal, S. Africa. (*Ingots, billets, slabs and plates.*)

Union Steel Corporation of South Africa, Ltd., "Usco" Steel Works, Vereeniging, Transvaal, S. Africa. (*Ingots, billets, small sections, castings and rivet bars.*

Vanderbijl Engineering Corporation, Ltd., Vanderbijl Park, Transvaal, South Africa. (*Castings.*)

**Vienna**

Works in Austria

Böhler, Gebr., & Co., Aktiengesellschaft, Vienna.

*Works:* Kapfenberg, Styria. (*Ingots, castings, forgings, bars and plates.*)

*Works:* Bruckbach, Low Austria. (*Rolling mills for sections and bars.*)

Klinger, Rich., Aktiengesellschaft, Gumpoldskirchen, near Vienna. (*Small castings.*)

Österreichisch - Alpine Montangesellschaft, Vienna.

*Works:* Donawitz, Styria. (*Sections and strip.*)

*Works:* Kindberg, Styria. (*Rolling mills for small sections, bars and strip.*)

*Works:* Traisen, Low Austria. (*Castings.*)

*Works:* Wördern, Low Austria. (*Ingots.*)

*Works:* Zeltweg, Styria. (*Forged bars.*)

Schoeller-Bleckmann Stahlwerke A.G., Vienna.

*Works:* Muerzzuschlag-Hoenigsberg, Styria. (*Bars.*)

*Works:* Ternitz, Low Austria. (*Castings, forgings and bars.*)

Steirische Gusstahlwerke, A.G., Vienna.

*Works:* Judenburg, Styria. (*Forgings and bars.*)

Vereinigte Österreichische Eisen-und-Stahlwerke A.G.

*Works:* Liezen, Styria. (*Ingots for forgings, castings.*)

*Works:* Linz a.d. Donau, Upper Austria. (*Plates, forgings and castings.*)

Waagner-Biro Aktiengesellschaft, Vienna, Austria.

*Works:* Werk C., Vienna. (*Castings.*)

Works in Czechoslovakia

Nová hut Klementa Gottwalda, národni podnik (New Metallurgical Works of Klement Gottwald, National Corporation), Ostrava - Kunčice. (*Ingots and forgings.*)

Třinecké železárny velké Říjnové socialistické revoluce, národni podnik (Třinec Iron Works Great Socialistic October Revolution National Corporation), Třinec. (*Ingots, sections, bars and castings.*)

**Vienna**—*continued*

Vítkovické Železárny Klementa Gottwalda, národni podnik (The Vitkovice Steel Works Klement Gottwald, National Corporation), Ostrava 10. (*Castings, forgings, plates, sections, bars and seamless tubes.*)

Závody V. I. Lenina Plzeň, národni podnik (V. I. Lenin Works Pilsen, National Corporation, formerly the Skoda Works, Pilsen), Plzeň. (*Castings and forgings.*)

Zelezárny a drátovny Bohumin, národni podnik (Iron Works & Wire Works Bohumin, National Corporation), Bohumin, Czechoslovakia. (*Small sections, bars and seamless tubes.*)

WORKS IN HUNGARY

Ganz-Mavag Mozdony Vagon es Gepgyar, Budapest. (*Castings and forgings.*)

K.G.M. Altalanos Gepipari Igazgatóság, Budapest.
*Works:* Öntödei Vallalat 1. sz. Gyára, Budapest. (*Castings.*)

K.G.M. Jarmuipari Igazgatóság, Budapest.
*Works:* Wilhelm Pieck Vagon es Gepgyar, Gyor. (*Castings.*)

K.G.M. Vaskohászati Igazgatóság, Budapest.
*Works:* Lenin Kohászati Müvek, Miskolc-Diósgyör. (*Ingots, slabs, sections, bars, castings and forgings.*)
*Works:* Dunai Vasnü, Dunaujváros. (*Ingots, slabs and plates.*)
*Works:* Dunai Vasmü, Lörinci Hengermüve, Budapest. (*Rolling mill for plates.*)
*Works:* Ozdi Kohászati, Uzemek, Ozd. (*Ingots, slabs, plates, sections and bars.*)

**Whyalla**

Broken Hill Proprietary Co., Ltd., Steel Foundry, and Rolling Mill, Whyalla, S. Australia. (*Castings, bars and sections.*)

**Winterthur**

de Roll, Société des Usines de Louis, Gerlafingen, Switzerland. (*Ingots, round bars and forgings.*)

Fischer, George, Ltd., Schaffhausen Switzerland. (*Castings.*)

Sulzer Bros. Ltd., Winterthur, Switzerland. (*Castings.*)

**Yokohama**

Ando Iron Works Co., Ltd., Tokyo, Japan. (*Small forgings.*)

Azuma Steel Works Ltd.
Azuma Plant, Tokyo, Japan. (*Ingots for plate.*)
Senju Plant, Tokyo, Japan. (*Rolling mills for plates.*)

Daido Steel Co., Ltd., Shibukawa Works, Shibukawa, Japan. (*Ingots, small forgings and bars.*)

Date Seiko Co., Ltd., Tokyo, Japan (*Castings.*)

**Yokohama**—*continued*

Fuji Iron & Steel Co., Ltd.
*Works at* Kamaishi, Japan. (*Sections and bars.*)
*Works at* Kawasaki, Japan. (*Rolling mills for strips for electric resistance welded tubes.*)
*Works at* Muroran, Japan. (*Billets, sections and bars.*)

Fukushima Seiko Co., Ltd., Fukushima, Japan. (*Castings.*)

Hakodate Dock Co., Ltd., Hakodate Shipyard, Hakodate, Japan. (*Small castings and forgings.*)

Hatakeyama Iron Works Co., Ltd., Komatsugawa.
*Works:* Tokyo, Japan. (*Small forgings.*)

Hitachi Ltd.
Hitachi Works, Hitachi, Japan. (*Castings.*)
Katsuta Works, Katsutashi, Inaragi-ken. (*Ingots, forgings and castings.*)

Hokuriku Kogyo Co., Ltd., Sanjo Plant, Sanjo, Niigata Prefecture, Japan. (*Small forgings.*)

Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo. Japan. (*Ingots, forgings and castings.*)

Japan Special Steel Co., Ltd., Tokyo, Japan. (*Ingots, forgings, blooms, billets and bars.*)

Japan Steel Works Ltd., Muroran Works, Muroran, Japan. (*Ingots, forgings, castings and plates.*)

Jonan Ironworks Co., Ltd., Haneda Works, Tokyo, Japan. (*Small forgings.*)

Kakegawa Endo Iron Works Co., Ltd., Kakegawa, Japan. (*Forgings.*)

Kanto Special Steel Works Ltd., Fujisawa, Kanagawa Pref., Japan. (*Forgings.*)

Kawaguchi Kinzoku Kogyo Kabushiki Kaisha, Kawaguchi, Japan. (*Castings.*)

Kawasaki Steel Corporation, Chiba Works, Chiba, Japan. (*Slabs and plates.*)

Kureha Seitetsu Co., Ltd., Toyama, Japan. (*Ingots.*)

Mitsubishi Nippon Heavy Industries, Ltd., Yokohama Shipyard and Engine Works, Yokohama, Japan. (*Ingots, blooms, small forgings and castings.*)

Mitsubishi Steel Manufacturing Co., Ltd., Tokyo, Japan.
Fukugawa Works. (*Billets and bars.*)
Hirota Works. (*Ingots.*)
Oshima Works. (*Rolling mills for billets and bars.*)

Nihon Cast Steel Co., Ltd., Tokyo, Japan. (*Ingots, forgings and castings.*)

Niigata Engineering Co., Ltd., Niigata, Japan. (*Castings, ingots and forgings.*)

Nippon Chuzo Kabushiki Kaisha, Kawasaki, Japan. (*Ingots and castings.*)

Nippon Kokan Kabushiki Kaisha.
Asano Dockyard, Yokohama, Japan. (*Small forgings.*)
Kawasaki Iron Works, Kawasaki, Japan. (*Tubes, bars and sections.*)
Mizue Ironworks, Kawasaki, Japan. (*Plates up to ½-inch in thickness.*)
Tsurumi Iron Works, Tsurumi, Yokohama, Japan. (*Ingots and plates.*)

**Yokohama**—*continued*

Nippon Stainless Steel Co., Ltd., Naoetsu Works, Niigata, Japan. (*Ingots, forgings and castings.*)

Nippon Yakin Kogyo Co., Ltd., Kawasaki, Japan. (*Ingots, forgings, bars and sheets.*)

Nisso Steel Manufacturing Co., Ltd.
- Naoetsu Factory, Naoetsu, Niigata, Japan. (*Ingots.*)
- Oshima Plant, Tokyo, Japan. (*Castings, plates and ingots for forging and plate.*)
- Toyama Factory, Toyama City, Japan. (*Ingots and forgings.*)

Nittoku Metal Industry Co., Ltd., Tokyo, Japan. (*Small forgings.*)

Osaka Shipbuilding Co., Ltd., Taira Steel Works, Taira City, Fukushima Prefecture, Japan. (*Castings.*)

Riken Tanzo Co., Ltd., Maebashi Plant, Maebashi, Japan. (*Small forgings.*)

Shimizu Tanzo Kabushiki Kaisha, Tokyo, Japan. (*Forgings.*)

Shin Nippon Tanko K.K., Kawasaki, Japan. (*Small forgings.*)

Sunnan Iron Works Co., Ltd., Yaizu, Japan. (*Forgings.*)

Takasaki Metal Industry Co., Ltd., Takasaki Plant, Takasaki, Japan. (*Small castings.*)

Tohoku Special Steel Works Ltd., Sendai, Japan. (*Ingots, small forgings, billets and bars.*)

**Yokohama**—*continued*

Tokushu Seiko (Special Steel Mfg.) Co., Ltd., Kawasaki *Works:* Kawasaki, Japan. (*Ingots, forgings and bars.*)

Tokyo Kikai Kabushiki Kaisha, Oshima Cast Steel *Works:* Tokyo, Japan. (*Castings.*)

Tokyo Shibaura Electric Co., Ltd., Turbine Works, Yokohama, Japan. (*Small castings.*)

Tokyo Steel Casting Co., Ltd., Tokyo, Japan. (*Castings.*)

Tokyo Tankosho Co., Ltd., Kawasaki Factory, Kawasaki, Japan. (*Small forgings.*)

Topy Industries, Ltd.
- Kanagawa Works, Chigasaki, Japan. (*Ingots for forging, castings.*)
- Tokyo Works, Tokyo, Japan. (*Sections.*)

Toshiba Steel Co., Ltd., Tokyo, Japan. (*Castings, small forgings, sections and ingots for forging and plates.*)

Uraga Shipbuilding Yard, Uraga Heavy Industries, Ltd., Yokosuka, Japan. (*Castings and small forgings.*)

Watanabe Steel Works Co., Ltd., Tokyo, Japan. (*Castings.*)

Yawata Steel Tube Co., Ltd., Tokyo Japan. (*Rolling mills for weldless rolled or drawn tubes.*)

Yokoyama Engineering Co., Ltd., Oshima 2nd Works, Tokyo, Japan. (*Castings.*)

## MANUFACTURERS OF ALUMINIUM ALLOYS

The following establishments have complied with the conditions contained in P 16 to P 18 of the Rules and are recognised by the Committee for the manufacture of aluminium alloys for shipbuilding purposes.

**United Kingdom**

Alcan Industries Ltd., Banbury. (*Aluminium alloys and products.*)

Alcan Industries Ltd., Newport, Mon. (*Aluminium alloys and products.*)

Almin Ltd.

- International Alloys Ltd., Aylesbury, Bucks. (*Aluminium alloys.*)
- Southern Forge Ltd., Langley, Bucks. (*Aluminium alloy products.*)

Aluminium Corporation Ltd., Dolgarrog, Caernarvonshire. (*Aluminium alloys and plates.*)

Aluminium Wire & Cable Co., Ltd., Port Tennant, Swansea. (*Aluminium alloys and products.*)

Birmetals Ltd., Quinton, Birmingham. (*Aluminium alloys and products.*)

James Booth Aluminium Ltd., Birmingham. (*Aluminium alloys and products.*)

British Aluminium Co., Ltd., Falkirk. (*Aluminium alloys and products.*)

British Aluminium Co., Ltd., Redditch Works, Birmingham. (*Aluminium alloys and products.*)

British Aluminium Co., Ltd., Rheola Works, South Wales. (*Aluminium alloys and products.*)

British Aluminium Co., Ltd., Bank Quay, Warrington. (*Aluminium alloys and products.*)

High Duty Alloys Ltd., Winscales, Workington. (*Aluminium alloys and products.*)

Imperial Aluminium Co., Ltd., Waunarlwydd, near Swansea. (*Aluminium alloys and products.*)

E. & E. Kaye, Ltd., Enfield, Middlesex. (*Aluminium alloys and products.*)

**Austria**

Vereinigte Metallwerke Ranshofen-Berndorf A.G., Braunau am Inn. (*Aluminium alloys and products.*)

**Belgium**

Ateliers Remi Claeys Lichtervelde. (*Aluminium alloy products.*)

Laminoirs de l'Escaut, Burcht. (*Aluminium alloy products.*)

S.A. Sidal, Société de l'Aluminium, Duffel. (*Aluminium alloys and products.*)

**Canada**

Aluminum Company of Canada, Ltd. (No. 1 Plant), Shawinigan Falls, Quebec. (*Aluminium alloy products.*)

Aluminum Company of Canada, Ltd., Etobicoke Works, Long Branch, Ont. (*Aluminium alloy products.*)

Aluminum Company of Canada, Ltd., Kingston, Ont. (*Aluminium alloys and products.*)

**France**

Aluminium Alcan de France, Luce (Eure & Loire). (*Aluminium alloys and products.*)

Compagnie Générale du Duralumin et du Cuivre (Cegedur).

- Blanc-Mesnil. (*Aluminium alloys and products.*)
- Chambery (Savoie). (*Aluminium alloy products.*)
- Faremoutiers (Seine & Marne). (*Aluminium alloys and products.*)
- Issoire (Puy de Dome). (*Aluminium alloys and products.*)
- Rive de Gier (Loire). (*Aluminium alloy products.*)

Soc. Cuivre et Alliages, Usine a Ham (Somme). (*Aluminium alloys and products.*)

Tréfimétaux, Montreuil-Belfroy. (*Aluminium alloy products.*)

**Germany**

Aluminiumwalzwerke Singen G.m.b.H., Singen (Hohentwiel). (*Aluminium alloys and products.*)

Otto Fuchs, Meinerzhagen. (*Aluminium alloys and products.*)

Osnabrücker Kupfer - und Drahtwerk, Osnabrück. (*Aluminium alloys and products.*)

Vereinigte Deutsche Metallwerke A.G., Frankfurt-Heddernheim. (*Aluminium alloys and products.*)

Vereinigte Leichtmetall-werke G.m.b.H., Bonn. (*Aluminium alloys and products.*)

Vereinigte Leichtmetall-werke G.m.b.H., Hanover. (*Aluminium alloys and products.*)

Westfälische Leichtmetall-werke, Nachrodt. (*Aluminium alloys and products.*)

**Holland**

N.V. Nederlandsche Aluminium Maats., Utrecht. (*Aluminium alloys and products.*)

**India**

Indian Aluminium Co., Ltd., Alwaye, Kerala State. (*Aluminium alloys and products.*)

Indian Aluminium Co., Ltd., Howrah, West Bengal. (*Aluminium alloys and products.*)

**Italy**

"Delta" Società Metallurgica Ligure S.p.A., Genoa. (*Aluminium alloys and products.*)

Lavorazione Leghe Leggere, Marghera (Venice). (*Aluminium alloys and products.*)

Montecatini Divisione Alluminio e Metalli, Feltre (Belluno) Works, Milan. (*Aluminium alloys and products.*)

Trafilerie E Laminatoi di Metalli S.p.A., Milan. (*Aluminium alloys and products.*)

**Japan**

Furukawa Aluminum Co., Ltd., Tokyo. (*Aluminium alloys and products.*)

Kobe Steel Works, Ltd., Shimonoseki. (*Aluminium alloys and products.*)

**Norway**

A/S Nordisk Aluminiumindustri, Oslo.
Hoyanger Works. (*Aluminium alloys.*)
Holmestrand Works. (*Aluminium alloy products.*)

Raufoss Ammunisjonsfabrikker, Raufoss. (*Aluminium alloy products.*)

**Poland**

Bielska Fabryka Wyrobow Srubowych, "Bispol", Bielsko-Biala. (*Aluminium alloy rivets.*)

Walcownie Metali.
Czechowice-Dziedzice Works. (*Aluminium alloy sections, bars and tubes.*)
Kety Works. (*Aluminium alloy, sections and tubes.*)

**Spain**

Aluminio Iberico, S.A., Alicante. (*Aluminium alloys and products.*)

Eduardo K. L. Earle, Lejona. (*Aluminium alloys and products.*)

**Sweden**

A/B Svenska Metallverken, Finspong. (*Aluminium alloys and products.*)

**Switzerland**

Aluminium Press & Walzwerk A. G., Munchenstein. (*Aluminium alloys and products.*)

Aluminium S.A., Menziken. (*Aluminium alloys and products.*)

Swiss Aluminium Ltd., Chippis. (*Aluminium alloys and products.*)

**Yugoslavia**

Tvornica Lakih Metala "Boris Kidric", Sibenik. (*Aluminium alloys and products.*)

## MANUFACTURERS OF STEEL WIRE ROPE

The following establishments have complied with the conditions contained in P 14 of the Rules and are recognised by the Committee for the manufacture of steel wire ropes.

**United Kingdom**

Binks Bros. Ltd., London.
British Ropes Ltd., Doncaster.
British Ropes Ltd., Gateshead-on-Tyne.
British Ropes Ltd., Glasgow.
British Ropes Ltd., London.
British Ropes Ltd., Retford.
Bruntons (Musselburgh) Ltd., Musselburgh.
Catherall Ropeworks Ltd., near Sunderland.
Joseph Crawhall & Sons Ltd., Gateshead-on-Tyne.
Dawson & Usher Ltd., Sunderland.
Dixon Corbitt Ltd., Gateshead-on-Tyne.
Edge & Sons Ltd., Shifnal.
Excelsior Ropes Group,
Comprising:—
Excelsior Ropes Ltd.,
Geo. Elliott & Co., Ltd.,
D. Morgan Rees & Sons Ltd.,
Bridgwater-Terrell Ropes Ltd.
Frew Bros. Ltd., Coatbridge.
Glaholm & Robson Ltd., Sunderland.
Glover Bros. (Mossley) Ltd., near Manchester.
The Gourock Ropeworks, Glasgow.
Hall's Barton Ropery Co., Ltd., Hull.
R. Hood Haggie & Son, Ltd., Newcastle-on-Tyne.
John I. Hopper Ltd., Thornaby-on-Tees.
Latch & Batchelor Ltd., Birmingham.
Martin, Black & Co. (Wire Ropes), Ltd., Coatbridge.
Overton Bros. Wire Ropes Ltd., Hull.
Rylands Bros., Ltd., Warrington.
Scottish Wire Rope Co., Ltd., near Glasgow.
John Shaw Ltd., Worksop.
Sheffield Wire Rope Co., Ltd., Sheffield.
Tyne Wire Ropes Ltd., South Shields.
Webster & Co., Ltd., Sunderland.
Whitecross Co., Ltd., Warrington.
Wrights' Ropes Ltd., Birmingham.

**Australia**

Australian Wire Rope Works Pty. Ltd.,Newcastle,N.S.W.

**Austria**

Felten & Guilleaume Fabrik Elektrischer Kabel, Vienna and Bruck an der Mur.
Joh. Pengg, Draht-und Walzwerke, Thörl bei Aflenz, Steiermark.
K. Teufelberger, Drahtseilwerke, Wels, Upper Austria.

**Belgium**

Anglo-Continental Ropes, Gilly.
"Cabcord" (Société Générale de Cablerie et Corderie), Hamme s/durme.
"Cabcord" (Société Générale de Cablerie et Corderie), Renory.
Cableries & Corderies du Hainaut, S.A., Dour, near Mons.
Cableries & Fonderies de & à Montignies s/Sambre.
Corderies J. B. Ligny, S.A. des Gilly.
Gonzalez Cock S.A., Lokeren.
Laurent Frères, Boussu-lez-Mons.
Le Lis, S.A., Hamme-sur-Durme.
Van Praet-Dansaert, Baasrode.
Vertongen-Goens S.A., Termonde.

**Brazil**

Cia. Industrial e Mercantil de Artefatos de Ferros, Sao Paulo.

**Canada**

British Ropes Canadian Factory (1963) Ltd., Vancouver.
Donald Ropes & Wire Cloth Ltd., Hamilton, Ontario.
Wire Rope Industries of Canada Ltd. (Canada Wire Ropes Ltd.), Smith Falls, Ontario.

**Denmark**

Jacob Holm & Sønners Fabriker, A/B., Copenhagen.
Randers Rebslaaeri A/S., Randers.

**Finland**

Oy Teräsköysi, Helsinki.

**France**

Etablissements Bessonneau, Angers, France.
Laminoirs-Tréfileries-Cableries de Lens, Lens.
Saint-Frères, S/A, Saint-Ouen, Somme.
Société des Aciéries & Tréfileries de Neuves-Maisons, Chatillon, Sainte-Colombe-sur-Seine (Cote d'Or).
Tréfilerie et Cablerie de l'Est, Buhl, Haut-Rhin.
Tréfilerie et Cablerie Julien Wurth et Cie., Reichshoffen.
Trefimetaux, Havre.

**Germany**

Ahlers, C.G., Hanf-u. Drahtseilfabrik, Bremerhaven.
Berkenhoff & Drebes A.G., Asslarer Hutte.
J. Bertram K.G. Drahtseilwerk, Soest.
Braucke, Adolf vom. A.G., Ihmerterbach.
Bremer Draht-und Seilindustrie G.m.b.H., Bremen-Hemelingen.
Dortmunder Drahtseilwerke G.m.b.H., Dortmund.
Drahtseilerei Gustav Kocks, Mülheim (Ruhr)—Broich.
Drahtseilwerke G.m.b.H., Bremerhaven.
Drahtseilwerke Hugo Wohlfahrt, Neheim/Ruhr.
Felten & Guilleaume, Koln-Mulheim.

**Germany**—*continued*

Gempt, J. H., Lengerich/Westf.
Hamburger Drahtseilerei G.m.b.H., Bad Oldesloe.
Hüttenwerk Oberhausen A.G. Werk Gelsenkirchen vorm. Boecker & Comp.
Klockner - Werke A.G. Dusseldorfer Drahtindustrie, Dusseldorf.
Norddeutsches Drahtseilwerk, A. Brinkmann, Syke.
Seilwerke Heinrich Puth K.G., Blankenstein, Ruhr.
J. & W. Vornbaumen K.G., Iburg.
Westdeutsche Seilindustrie Paul Stoessel, Osterrath b/Dusseldorf.
Westfalische Drahtindustrie, Hamm.
Westfalische Union A.G., Lippstadt.
Westfalische Union A.G. fur Eisen und Drahtindustrie, Drahtseilwerk Oesede.
Wolf, Gustav, Gutersloh.

**Holland**

Staaldraadkabel & Herculestouwfabriek J.C. den Haan, Gorinchem.
Vereenigde Touwfabrieken, Leiderdorp.

**Hong Kong**

Hong Kong Steel Ropes Ltd., Kowloon.

**India**

National Rolling & Steel Ropes Ltd., Calcutta.
J. K. Steel Ltd., Calcutta.
Usha Martin Black Wire Ropes Ltd., Ranchi.

**Israel**

Wire Rope Works Messilot Ltd., Doar Na Gilboa.

**Italy**

Acciaierie Ferriere Lombarde Falck, Sesto San Giovanni.
Giuseppe & Fratello Redaelli S.p.A.,—Gardone val Trompia (Brescia), Brescia.
"Italsider" Alti Forni & Acciaierie Riunite Ilva e Cornigliano, S.p.A., Sezione di Torre Annunziata.
Industrie Metallurgiche Piemontesi, Susa.
Ing. Guido Scolari (Soc., Acc., Semp.), Milan.
Stabilimenti G. Fornara & Co., Turin.

**Japan**

Asahi Wire Rope Manufacturing Co. Ltd., Osaka.
Daido Wire Rope Mfg. Co., Ltd., Osaka.
Dainichi Seiko Co., Ltd., Sakoshi.
Kasuga Seiko K.K., Osaka.
Kawasaki Steel Corporation, Chiba Iron and Steel Works, Chiba City.
Kokoku Iron & Steel Wire Mfg. Co. Ltd., Niigata.
Kokoku Iron & Steel Wire Mfg. Co. Ltd., Osaka.
Kokoku Iron & Steel Wire Mfg. Co. Ltd., Tokyo.
Nippon Steel Wire & Wire Rope Co. Ltd., Osaka.

**Japan**—*continued*

Nishida Wire Rope Mfg. Co. Ltd., Osaka.
Sensyu Seiko Co. Ltd., Kaizuka.
Shinko Wire Co. Ltd., Amagasaki.
Showa Wire Rope Mfg. Co. Ltd., Osaka.
Tatsumi Rope Mfg. Co. Ltd., Osaka.
Teikoku Sangyo Kabushiki Kaisha, Osaka.
Tokyo Seiko Kaisha, Kokura.
Tokyo Seiko Kaisha, Tokyo.
Toyo Wire Rope Manufacturing Co. Ltd., Osaka.

**Mexico**

Cables Mexicanos S.A., Mexico.

**Norway**

Mandal Stal A/S, Mandal.
Norsk Staaltaugfabrik, Trondheim.
Tonsberg Reperbane A/S., Tonsberg.

**Poland**

Fabryka Lin i Drutu, Bytom Karb.
Sosnowiecka Fabryka Lin i Drutu, Sosnowiec.

**Portugal**

Cordoaria Lisbonense, Lisbon.
Quintas and Quintas, Povoa do Varzim.
Rodrigues d'Oliveira, M., Sa & Fos, Ltda., Oporto.

**South Africa**

African Wire Ropes Ltd.
(Rand Ropes Ltd., Germiston).
(Haggie, Son & Love (1936) Ltd. Cleveland).

**Spain**

Franco Espanola de Alambres, S.A., Bilbao.
"Nueva Montana Quijano", S.A., Santander.
Trenzas y Cables de Acero S.A., Barcelona.

**Sweden**

Blombacka A/B., Lindfors.
Fagersta Bruks A/B., Fagersta.
Garphytte Bruks A/B., Garphyttan.
Lesjofors A/B., Lesjofors.
Stallinefabriken, David Ahlquist A/B., Roslags-Nasby.
Svenska Stållinor, A/B., Varberg.

**United States of America**

The Wire Rope Corporation of America, Missouri.

**Yugoslavia**

Novosadska Fabrika Kabela, Novi Sad.
"Otocanka", Zadar.

## PROVING ESTABLISHMENTS

The following proving establishments are recognised by the Committee of Lloyd's Register for the testing of anchors and chains while licensed by the Ministry of Transport for that purpose.

*Principal Superintendent:* Mr. H. Murphy. (*Stationed at Netherton.*)

| | *Superintendents* |
|---|---|
| Netherton (near Dudley)—Lloyd's Proving House ... ... ... ... | Mr. H. Murphy |
| Low Walker-on-Tyne—Lloyd's Proving House ... ... ... ... ... | Mr. R. J. Vogan |
| Burnbank—Lloyd's Proving House ... ... ... ... ... ... ... | Mr. S. Bolton |
| Cardiff—Lloyd's Proving House ... ... ... ... ... ... ... | Mr. T. H. Whitworth |

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The following machines have been recognised by the Committee for the testing of anchors and chain cables except for anchors and chain cables bought or sold in the United Kingdom for use on a British ship which are to be tested at a licensed Proving House in the United Kingdom.

**Argentine**

Direccion General de Administracion Naval, Buenos Aires, Argentine.

**Australia**

Falkiner Chains Pty. Ltd., South Brisbane, Queensland (for testing chain cables up to 100 tons).

**Austria**

Ferdinand Freiherr v. Helldorff & Otto Rothart Kettenwerk Brückl, Brückl, Carinthia.

Steirische Kettenfabriken Pengg-Walenta Kommanditgesellschaft, Werk Hansenhütte, Kapfenberg-Hansenhütte, Styria.

**Belgium**

Adh. Demanet, Gosselies (for testing chains up to 300 tons).

Béliard, Murdoch & Co., Antwerp (for testing anchors and chain cables up to 100 tons).

Mercantile Marine Engineering & Graving Dock Co., Antwerp.

Usines et Aciéries Allard S.A., Mont-sur-Marchienne (for testing anchors only.)

**Canada**

Canada Chain & Forge Co., Ltd., Granville Island, Vancouver, B.C.

Dominion Chain Co., Ltd., Niagara Falls, Ontario.

**Czechoslovakia**

Trinecké železárny, Velké rijnové Socialistické revoluce, narodni podnik, Retezárna Mala Morávka. (Trinec Iron Works Great Socialistic October Revolution National Corporation, Chain Works Mala Moravka).

**Denmark**

Orlogsværftet, Holmen, Copenhagen.

**Finland**

Fiskars A.B., Loimaa.

Wärtsilä-Koncernen A/B., Dalsbruk Järnverk, Helsingfors (for testing chain cables up to 250 tons).

**France**

Carlier et Cie., St. Amand-les-Eaux (Nord).

Davaine, Fils et Cie., St. Amand-les-Eaux (Nord) (for testing chain cables up to 132 tons).

Ets. Marit, St. Amand-les-Eaux (Nord).

**France**—*continued*

Etablissement Sirot-Mestreit, St. Amand-les-Eaux (Nord).

Fonderies Meridionales, Marseilles (for testing anchors only).

Forges Nationales de la Chaussade à Guérigny, Nièvre (for testing chain cables up to 300 tons).

Paoli, J., & Co., Marseilles.

Société Anonyme des Chaîneries de St. Amand-les-Eaux, Etablissements Dorémieux Fils & Cie., St. Amand-les-Eaux (Nord).

Société des Forges des Fresnes, Fresnes-sur-Escaut (Nord) (for testing chain cables up to 150 tons).

Veille, A., & Co., Le Havre.

**Germany**

Dortmund-Hoerder Hüttenunion A.G., Dortmund Works, Dortmund (for testing anchors only).

Dortmunder Kettenfabrik Bernhard Mester, Wetterstr. 10, Dortmund.

Fröndenberger Kettenfabrik, Heinrich Prünte, Frondenberg-Ruhr (for testing chain cables up to 120 tons).

Hansa Kettenfabrik Haunschild & Co., Dortmund.

Howaldtswerke A.G., Hamburg.

Joto-Werk Josef Topp, Kettenfabrik, Warmen (Ruhr).

Kettenfabrik Kalthof, August Thiele; and August Thiele G.m.b.H., Fabrik für Ketten und Kettenforderer, Kalthof, near Schwerte-Ruhr.

Kettenwerke Schlieper, Grune, Westphalia.

Mannheimer Ankerfabrik u. Hammerwerk Gdbr. Heuss, Mannheim-Industriehafen (Ruhr).

Stülcken, H. C., Sohn, Schiffswerft und Maschinenfabrik, Hamburg.

Theile, J. D., Schwerte-Ruhr.

**Holland**

Koninklijke Nederlandsche Grofsmederij, Leiden.

N.V. Anker-& Kettingfabriek "Schiedam" (*Managing Director:* P. Th. Verhoeff), Schiedam.

**Hong Kong**

The Taikoo Dockyard & Engineering Co. of Hong Kong Ltd.

**India**

The Commissioners for the Port of Calcutta, Calcutta.

**Italy**

Acciaieria e Ferriera del Caleotto S.p.A., Lecco.

Acciaierie Weissenfels, Catenificio, Fusine di Valromana, Udine (for the testing of small chains only).

**Japan**

Hamanaka Chain Manufacturing Co., Ltd., Himeji.

Japan Mechanical Chain Manufacturing Co., Ltd., Osaka

Komatsu Manufacturing Co., Ltd., Komatsu.

Komatsu Manufacturing Co., Ltd., Osaka Plant, Hirakata.

Koyo Chain Manufacturing Co., Ltd., Osaka.

Onomichi Anchor Manufacturing Co., Ltd., Onomichi (for testing anchors only).

Osaka Chain & Machinery Manufacturing Co., Ltd., Kaizuka Works, Osaka.

Toa Seisa Co., Ltd., Himeji.

Tokyo Chain Works Co., Ltd., Tokyo.

Tokyo Steel Casting Co., Ltd., Tokyo.

**Norway**

A/S Kjættingfabriken, Helle (for testing chain cables up to 30 tons).

Norsk Kjettingindustri A/S, Mandal.

**South Africa**

McKinnon Chain (South Africa) (Pty.) Ltd., Vereeniging, Transvaal.

**Spain**

Cadenas y Forjádos, S.A., J. M. Olavarri, Bilbao. *Works:* Lejona, Bilbao.

Don Ciriaco Rodriguez Dorado, Barcelona (for testing chain cables up to 30 tons).

Forjas de San Martin de Pedro Framis, Barcelona (for testing chains up to 16 tons).

Vicinay, S.A., Duesto.

**Sweden**

Gunnebo Bruks Aktiebolag, Gunnebobuck, Västervik (for testing chains up to 75 tons).

Jarnbirger A/B, Orsa.

Ljusne Woxna Aktiebolag, Ljusne.

Ramnäs Bruks Aktiebolag, Ramnäs.

Statens Provningsanstalt (Government Establishment), Stockholm.

**United Kingdom**

Brown, Lenox & Co., Ltd., Pontypridd, Monmouthshire.

North British Electric Welding Co., Ltd., Coatbridge, Lanarkshire.

Taylor, Samuel, & Sons (Brierley Hill) Ltd., Brierley Hill, Staffs.

The British Steel Chain Co., Ltd., Powke Lane, Old Hill, Staffs.

**United States**

American Anchor & Chain Corporation, Fieldsboro, N.J.

American Chain Co., Braddock, near Pittsburgh, Pa.; and York, Pa. (for testing chains up to 22 tons).

Baldt Anchor, Chain and Forge Division of the Boston Metals Co., Chester, Pa.

Bellingham Chain & Forge Co., South Bellingham, Wash.

Buckeye Steel Castings Co., Columbus, O. (for breaking tests on chain cables only).

Johnson-Farmer Chain Division of the Boston Metals Co., Lebanon, Pa.

McKay Company, McKees Rocks, near Pittsburgh, Pa.

**United States**—*continued*

National Castings Co., Sharon, Pa.

National Erie Co., Erie, Pa. (for testing anchors only).

Pacific Chain & Manufacturing Co., Portland, Or.

Republic Steel Corporation, Round Chain Division. Broadway & Chaincraft Roads, Cleveland, O. 6921, East Marginal Way, Seattle 8, Wash.

Taylor, S. G., Chain Company, Hammond, Indiana.

**Yugoslavia**

Tovarna Verig, Lesce pri Bledu.

N.B.—Ships supplied with anchors and chain cables tested at any of the establishments in the foregoing lists will have the notation of LACP in the Appendix to the Register Book, provided that in the case of machines other than at licensed Proving Houses in the U.K., the tests are carried out under the supervision of a Surveyor to the Society.

## ELECTRICALLY WELDED STEEL CHAIN CABLES

and

## CAST STEEL CHAIN CABLES

The following establishments have complied with the requirements for manufacture of electrically welded and cast steel chain cables and have been recognised by the Committee:—

GRADE I (c) *Flash butt welded chain cables of mild steel having a tensile breaking strength of 20 to 26 tons per sq. inch.*

GRADE II *Flash butt welded chain cables of mild steel having a tensile breaking strength of 26 to 32 tons per sq. inch.*

GRADE III (a) *Flash butt welded or drop forged special steel having a tensile breaking strength of 32 to 40 tons per sq. inch.*

III (b) *Cast Steel having a tensile breaking strength of 32 to 40 tons per sq. inch.*

NOTE: Before acceptance on classed ships chain cables must be tested on a chain cable testing machine recognised by the Society.

| FIRM | GRADE & TRADE NAME (IF ANY) | MAXIMUM DIAMETER | SURVEYING DISTRICT |
|---|---|---|---|
| **United Kingdom** | | | |
| Beal & Son (Cable Makers) Ltd., Cardiff. | I (c), II & III (a) | 4 ins. | Cardiff |
| Bradney Chain & Engineering Co., Ltd., Cradley Heath. | II (Short link) | $\frac{1}{2}$ in. | Birmingham |
| British Steel Chain Co. Ltd., Old Hill, Staffs. | I (c), II & III (a) | 2 ins. | Birmingham |
| Brown, Lenox & Co. Ltd., Pontypridd. | I (c), II & III (a),<br>III (b) | 4 ins.<br>3 ins. | Cardiff |
| Chain Developments Ltd., (N. Hingley & Co. Ltd.), West Bromwich. | I (c) & II | $1\frac{1}{4}$ ins. | Birmingham |
| Griffin-Woodhouse Ltd., Cradley Heath, Staffs. | III (a) | $2\frac{3}{16}$ ins. | Birmingham |
| North British Electric Welding Co. Ltd., Whifflet, Coatbridge, Lanarkshire. | I (c), II & III (a) | $4\frac{1}{8}$ ins. | Glasgow |
| Parsons Chain Co. Ltd., Stourport-on-Severn. | I (c), II & III (a) (Short link) | $1\frac{1}{4}$ ins. | Birmingham |
| Taylor, Samuel, & Sons (Brierley Hill) Ltd., Brierley Hill, Staffs. | I (c) & II<br>III (a) (Tayco)<br>III (a) (New Process Tayco) | $4\frac{1}{8}$ ins.<br>$4\frac{1}{8}$ ins.<br>$3\frac{5}{16}$ ins. | Birmingham |
| Watson & Maclean Ltd., Glasgow. | III (a) (Short link) | $\frac{7}{8}$ in. | Glasgow |
| Wheway, Job, & Sons Ltd., Birchills Hame & Chain Works, Walsall. | I (c)<br>II (Short link) | $\frac{7}{8}$ in.<br>$\frac{11}{16}$ in. | Birmingham |

| Firm | Grade & Trade Name (if any) | Maximum Diameter | Surveying District |
|---|---|---|---|
| **Australia** | | | |
| Falkiner Chains Pty. Ltd., South Brisbane. | I (c)<br>III (a)<br>(Famac) | $2\frac{5}{16}$ ins.<br>2 ins. | Brisbane |
| **Austria** | | | |
| Ferdinand Freiherr v. Helldorff & Otto Rothart Kettenwerk Brückl, Brückl. | I (c)<br>(Short link) | 26 mm. | Vienna |
| Steirische Kettenfabriken Pengg-Walenta Kommanditgesellschaft, Styria. | I (c)<br>II & III (a) | 44 mm.<br>41 mm. | Vienna |
| **Belgium** | | | |
| Adh-Demanet, Gosselies. | I (c), II & III (a) | 76 mm. | Antwerp |
| **Czechoslovakia** | | | |
| Třinecké Železárny Velke Rijnové Socialistické Revoluce, Národni Podnik, Řetězárna Malá Morávka (Trinec Iron Works Great Socialistic October Revolution National Corporation, Chain Works Malá Morávka). | I (c) & II | 46 mm. | Vienna |
| **Finland** | | | |
| Fiskars A.B., Loimaa. | I (c) | 36 mm. | Abo |
| Wartsilä-Koncernen A.B., Dalsbruks Järnverk, Dalsbruk. | I (c), II & III (a) | 64 mm. | Abo |
| **France** | | | |
| M. Carlier & Cie., St.-Amand-les-Eaux, Nord. | I (c) & II | 30 mm. | Valenciennes |
| Davaine Fils et Cie., St.-Amand-les-Eaux, Nord. | I (c) & II | 30 mm. | Valenciennes |
| Forges Nationales de la Chaussade, Guerigny. | III (a) | 80 mm. | Marseilles |
| Manufacture de Chaines et Ancres de Saint-Amand, St.-Amand-les-Eaux, Nord. | | | |
| Usine A, Ets Sirot Mestreit | I (c), II & III (a) | 80 mm. | Valenciennes |
| Usine B, Ets Dorémieux | I (c), II & III (a) | 100 mm. | Valenciennes |
| Etablissements Marit, Saint-Amand-les-Eaux, Nord. | I (c) & II | 44 mm. | Valenciennes |
| Soc. des Forges de Fresnes, Fresnes sur Escaut, Nord. | I (c) & II<br>III (a) | 65 mm.<br>60 mm. | Valenciennes |
| A. Veille et Cie., Le Havre. | I (c), II & III (a)<br>I (c), II & III (a)<br>(Monobloc) | 100 mm.<br>91 mm. | Havre |

| Firm | Grade & Trade Name (if any) | Maximum Diameter | Surveying District |
|---|---|---|---|
| **Germany** | | | |
| Dortmunder Kettenfabrik B. Mester, Dortmund. | I (c) & III (a) | 69 mm. | Dortmund |
| Hansa-Kettenfabrik Haunschild & Co., Dortmund. | I (c)<br>III (a) | 90 mm.<br>75 mm. | Dortmund |
| Joto-werk, Josef Topp Kettenfabrik, Warmen (Ruhr). | I (c) & II<br>III (a) | 68 mm.<br>62 mm. | Dortmund |
| Kettenfabrik Kalthof, August Thiele; August Thiele G.m.b.H. Fabrik für Ketten und Kettenforderer, Kalthof, near Schwerte-Ruhr. | I (c), II & III (a) | 105 mm. | Dortmund |
| Kettenwerke Schlieper, Grune-Westfalen. | I (c), II & III (a) | 110 mm. | Dortmund |
| Theile, J. D., Schwerte-Ruhr. | I (c), II & III (a) | 92 mm. | Dortmund |
| **Holland** | | | |
| Anker-En Kettingfabriek "Schiedam", Schiedam. | III (a) | 78 mm. | Rotterdam |
| Koninklijke Nederlandsche Grofsmederij, Leiden. | I (c), II & III (a) (Ego)<br>I (c) & II (Eldam)<br>I (c), II & III (a) | 93·5 mm.<br>75 mm.<br>105 mm. | Rotterdam |
| **Italy** | | | |
| Acciaieria e Ferriera del Caleotto, Lecco. | I (c), II & III (a) | 90 mm. | Milan |
| **Japan** | | | |
| Hamanaka Chain Manufacturing Co. Ltd., Himeji. | III (a) | 94 mm. | Kobe |
| Japan Mechanical Chain Manufacturing Co. Ltd., Osaka. | III (a) (Kikai)<br>I (c), II & III (a) (Flash welded) | 64 mm.<br>58 mm. | Kobe |
| Komatsu Manufacturing Co. Ltd., | | | |
| Osaka Works | III (a) | 97 mm. | Kobe |
| Komatsu Works | III (b) | 114 mm. | Kobe |
| Koyo Chain Mfg. Co., Ltd., Osaka. | I (c), II & III (a) | 42 mm. | Kobe |
| Osaka Chain & Machinery Mfg. Co., Ltd., Osaka. | III (a)<br>III (b) | 97 mm.<br>89 mm. | Kobe |
| Tokyo Chain Works Co. Ltd., Tokyo. | I (c), II & III (a) | 102 mm. | Yokohama |
| Tokyo Steel Casting, Co. Ltd., Tokyo. | III (b) | 89 mm. | Yokohama |

| Firm | Grade & Trade Name (if any) | Maximum Diameter | Surveying District |
|---|---|---|---|
| **Norway** | | | |
| Kjettingfabriken, A/S, Helle. | I (c) (Short link) | 19 mm. | Oslo |
| Norsk Kjettingindustri A/S, Mandal. | I (c) (Short link) | 25 mm. | Oslo |
| | I (c) (Stud link) | 32 mm. | |
| | III (a) (Stud link) | 27 mm. | |
| **South Africa** | | | |
| Cotts Steel Industries (Pty.) Ltd., Johannesburg | I (c), II & III (a) | $1\frac{1}{8}$ in. | Vereeniging |
| McKinnon Chain (South Africa) (Pty.) Ltd., Vereeniging. | I (c) (Short link) | $\frac{3}{4}$ in. | Vereeniging |
| **Spain** | | | |
| Cadenas y Forjados, Bilbao. | I (c), II & III (a) | 73 mm. | Bilbao |
| Vicinay S.A., Deusto. | I (c), II & III (a) | 79·5 mm. | Bilbao |
| **Sweden** | | | |
| Gunnebo Bruks Aktiebolag, Gunnebobruk. | I (c) & II | 16 mm. | Stockholm |
| Jarnbirger A/B, Orsa. | I (c), II & III (a) | 55 mm. | Stockholm |
| Ljusne-Woxna Aktiebolag, Kattingfabriken, Ljusne. | I (c), II & III (a) | 92 mm. | Stockholm |
| Ramnäs Bruks Aktiebolag, Ramnäs. | I (c), II & III (a) | 98 mm. | Stockholm |
| **United States of America** | | | |
| Baldt Anchor, Chain & Forge Division, Chester, Pennsylvania. | III (a) (Weld in alternate links) | $\frac{5}{8}$ in. | Philadelphia |
| | III (a) (Flash welded) | $4\frac{1}{4}$ ins. | |
| The National Castings Co., Sharon, Pennsylvania. | III (b) (Naco) | $3\frac{1}{2}$ ins. | Pittsburg |
| The Pacific Chain & Manufacturing Co., Oregon. | I (c), II & III (a) | $2\frac{7}{16}$ ins. | Seattle |
| **Yugoslavia** | | | |
| Tovarna Verig, Lesce. | I (c), II & III (a) | 100 mm. | Rijeka |

# Chapter R

# PROVISIONAL RULES AND GUIDANCE NOTES

*Explanatory Notes*

**PROVISIONAL RULES** give requirements which have been framed primarily for the initial regulation of ship and machinery applications in process of development ; they are subject to continuous review.

**GUIDANCE NOTES** are intended as recommendations to designers, based on good practice, in matters for which the present state of knowledge does not justify precise requirements.

## R (A)—PROVISIONAL REQUIREMENTS FOR THE USE OF METHANE GAS AS FUEL FOR THE PROPULSION OF METHANE TANKERS

### Section 1

**General**

**101** In methane tankers the methane "boil-off" may be used as fuel for propulsion services subject to compliance with the following requirements or equivalents; it is not to be used for firing donkey or domestic boilers or for auxiliary engine services.

**102** These provisional requirements are based on the assumption that the pressure of the gas supply to the machinery space will not exceed 15lb. per square inch (1 kg. per cm.$^2$) gauge for boilers, and 100lb. per square inch (7 kg. per cm.$^2$) gauge for oil engines, and that the gas temperature in both cases will be approximately ambient. Where higher pressure or temperature conditions are proposed the arrangements will be specially considered.

It is also assumed that adequate oil fuel bunkers will always be carried and that the ship will not be entirely dependent on the methane "boil-off" for fuel requirements during any voyage.

**Plans**

**103** The following plans are to be submitted for consideration:—

General arrangement of plant.
Gas piping system, together with details of interlocking and safety devices.
Gas heaters.
Gas compressors and their prime movers.
Gas storage pressure vessels.
Gas and oil fuel burning arrangements.

**Equipment for Heating, Compressing and Storing Methane Gas**

**104** The methane gas is to be heated and compressed outside the machinery space. If the gas is stored in a pressure vessel the latter is also to be located outside the machinery space.

**105** Gas heaters and compressors, of watertight construction, may be installed on the open deck provided they are suitably located and protected from mechanical damage. Alternatively, the heaters and compressors may be installed in a well ventilated compartment outside the machinery space. This compartment is to be treated as a dangerous space to which the requirements of M 16 for electrical equipment are applicable.

**106** If steam is adopted as the heating medium the steam supply to the heaters is to be automatically controlled by the discharge temperature of the methane from the heaters, and the steam drains are to be led to a vented drain tank outside the machinery space. The vents are to be led to a safe position.

**107** The prime movers for the gas compressors are to be regulated to maintain a positive suction pressure and arranged to stop automatically if the pressure on the suction side of the compressors is lower than $\frac{1}{2}$lb. per square inch gauge (0,035 kg. per cm.$^2$) or other approved positive pressure appropriate to the cargo tank system. They are also to be capable of being stopped, in emergency, from suitable positions on deck and in the machinery space.

**108** Gas compressors of the piston type are to be fitted with relief valves discharging to a safe position. The relief valves are to be so proportioned and adjusted that the accumulation with the outlet valves closed will not exceed 10 per cent of the maximum working pressure.

**109** The suction and discharge connections to the compressors are to be fitted with isolating valves and flame arresters.

**110** Pressure vessels for storing methane gas are to be of approved design and fitted with pressure relief valves discharging to atmosphere in a safe position.

**Ventilation of Machinery Spaces**

**111** Efficient arrangements are to be provided for the thorough ventilation of the machinery space under all climatic conditions and are to include a monitoring system with visual and audible warnings to detect gas leaks.

**Gas Supply Pipes in Machinery Spaces**

**112** The gas supply lines in the machinery space are to be fitted in trunks or casings which are maintained by exhaust fans at a pressure slightly below that prevailing in the machinery space. The fans are to be of a type in which the electric motor is outside the ducting. The air discharge is to be led to a safe position and is to be monitored for methane leakage. Alternatively, the supply lines may be contained in trunks or casings pressurised by an inert gas at a pressure appreciably higher than the methane gas pressure. The gas supply lines are to be located remote from the ship's sides. Indicators of the trunk ventilation or pressurisation are to be provided.

**113** The gas supply lines in the machinery space are to have all-welded joints so far as practicable, and are to be tested in place by hydraulic pressure to 100lb. per square inch (7 kg. per cm.2) or twice the working pressure, whichever is the greater. Subsequently, the lines are to be tested by air at the working pressure using "Soapy Water", or equivalent, to verify that all joints are absolutely tight.

**114** Provision is to be made at a suitable position on deck for shutting off the gas supply before it enters the machinery space.

**Purging Arrangements**

**115** Arrangements are to be made for purging the complete methane system with an inert gas or steam before and after pipes, auxiliaries, etc., are opened up for inspection or overhaul.

**Electrical Equipment**

**116** The location of electrical equipment, including switchboard, is to be such that an accumulation of gas in the vicinity of such equipment is not possible.

## MAIN BOILERS

**Requirements for Burning Methane Gas**

**117** The boilers are to be equipped for oil firing in addition to the gas firing. Oil fuel alone is to be used for starting-up, port operations and manœuvring.

**118** The boiler room is to be separated from the engine room by a bulkhead, roller fire screen or equivalent. Each boiler is to have a separate uptake to the top of the funnel or a separate funnel.

**119** The draught arrangements are to be such that a pressure differential is maintained between the boiler room and the combustion chamber either by induced draught fans or by a closed stokehold system of forced draught. Alternatively, the boilers may be enclosed in a pressurised air casing.

**120** The gas manifolds together with control valves are to be contained in a casing which is maintained below engine room pressure by an exhaust fan discharging to a safe position. Alternatively, the gas manifolds, valves, etc., may be contained in casings pressurised by inert gas as described in 112.

**121** The firing equipment is to be of combined gas and oil type and be capable of burning both fuels simultaneously. The gas nozzles are to be so disposed as to obtain ignition from the oil flame which is to be present under all conditions of firing. A mechanical inter-locking device is to be provided to prevent the gas supply being opened until the oil and air controls are in the firing position. Each burner supply pipe is to be fitted with a gas shut-off cock and a flame arrester unless the latter is incorporated in the burner. An audible alarm is to be provided giving warning of loss of minimum effective pressure in the oil fuel discharge line or failure of the fuel pump.

**122** Arrangements are to be made so that the gas supply to the gas manifold at each boiler can be shut off manually at the firing platform and will be shut off automatically as a result of failure of the forced draught fans or too low a pressure in the gas supply line.

**123** An inert gas or steam purging connection is to be provided on the burner side of the shut off arrangements required by 122 so that the pipes to the gas nozzles can be purged immediately before and after methane gas is used for firing purposes.

**124** A notice board is to be provided at the firing platform stating:—

> If ignition is lost from both oil and gas burners, the combustion spaces are to be thoroughly purged of all combustible gases before re-lighting the oil burners.

## MAIN OIL ENGINES

### Requirements for Using Methane Gas

**125** Main engines are to be of the dual fuel type employing pilot oil fuel ignition and capable of immediate change-over to oil fuel only. All starting and manœuvring is to be carried out on oil fuel alone.

**126** The gas is to be admitted to each cylinder via a separate gas inlet valve; i.e. a system whereby gas is supplied to and mixed with air in a common inlet manifold is not acceptable from safety considerations. The gas supply pipes to individual cylinders are to be fitted with shut-off valves, non-return valves and flame arresters.

**127** Isolating valves are to be provided at the inlet to the gas supply manifold for the engine and are to be arranged to close automatically in the event of low gas pressure and failure of pilot fuel injection. Arrangements are to be made so that the gas supply to the engine can be shut off manually from the starting platform.

**128** Explosion relief valves are to be provided in the exhaust, scavenge and air inlet manifolds for conditions where, for example, a cylinder misfires due to failure of the pilot fuel injection or other derangement.

**129** A cowl or casing connected to an exhaust ventilator is to be fitted over the cylinder tops so that gas leakages may be intercepted and led to a safe position. No electrical equipment is to be fitted inside these cowls and casings.

**130** If a trunk piston engine is used the crankcase is to be fitted with smoke detecting equipment and means for the automatic injection of inert gas to avoid the special hazard of an explosion in a crank case which normally will contain a methane/air mixture. Crank case relief valves are also to be fitted as required by H 7.

### Survey

**131** The gas compressors, heaters, pressure vessels and piping are to be constructed under Special Survey, and the installation of the whole plant on board the ship is to be carried out under the supervision of the Society's Surveyors.

*28th February, 1963*

## R (B)—PROVISIONAL REQUIREMENTS FOR PLASTIC PIPES

### Section 1

**101** Proposals to use plastic type materials in shipboard piping systems will be considered in relation to the properties of the materials, the operating conditions of temperature and pressure, and the intended service.

The requirements which follow are intended for extruded plastic pipes; they may also be used, where applicable, for fabricated plastic pipes glass reinforced. Any proposed service for plastic pipes not mentioned in these requirements is to be submitted for special consideration.

**102** A specification of the plastic material giving mechanical and thermal properties is to be submitted for consideration.

**103** In general, plastic pipes are not to be used where they will be subjected to temperatures above 120° F. (49° C.) or below 32° F. (0° C.).

**104** Plastic pipes of approved type may be used for the following services:—

(*a*) Air and sounding pipes to tanks used exclusively for carrying water ballast or fresh water, with the exception of the portion above deck.

(*b*) Sounding pipes to cargo holds.

(*c*) Water ballast and fresh water pipes situated inside tanks used exclusively for carrying water ballast or fresh water.

(*d*) Scupper pipes draining inboard provided they are not led within the boundaries of refrigerated chambers.

Items (*a*) and (*b*) are not applicable to passenger ships.

**105** Plastic pipes may be used for domestic and similar services for which there are no rule requirements, as follows:—

Domestic cold salt and fresh water systems.

Sanitary salt water systems.

Sanitary and domestic waste pipes wholly situated above the freeboard deck.

Water pipes associated with air conditioning plants.

**106** Since plastic materials are generally heat sensitive and very susceptible to fire damage, plastic pipes will not be acceptable for services essential to safety, as follows:—

Fire extinguishing pipes.

Bilge pipes in cargo holds.

Bilge and ballast pipes in the machinery space.

Main and auxiliary water circulating pipes.

Feed and condensate pipes.

Pipes carrying oil or other inflammable liquids.

**107** If plastic pipes are arranged to pass through watertight or fire-resisting bulkheads or decks provision is to be made for maintaining the integrity of the bulkhead or deck in the event of pipe failure. Details of the arrangements are to be submitted for approval.

**108** Pipes are to be of robust construction, and in general so designed that the wall stress will not exceed $\frac{1}{7}$ of the tensile strength of the material at the working temperature. Particulars of scantlings and joints are to be submitted for consideration.

**109** All pipes are to be adequately but freely supported; suitable provision for expansion and contraction is to be made in each range of pipes to allow for large movements between plastic pipe and steel structure—the coefficient of thermal expansion for plastics being eight or more times that of steel.

**110** All fittings and branches are to be suitable for the intended service having joints of cemented, flanged, or other approved type.

**111** The strength of the plastic material is to be check tested at the Surveyor's discretion. The tensile strength is to be determined by pressure tests to destruction on sample pipes. The pressure is to be so applied that failure of the pipe occurs in not less than five minutes. Bulging of the pipe during test is acceptable. The tensile strength is to be taken as the hoop stress at failure based on the original pipe dimensions.

*28th February, 1963*

# R (C)—PROVISIONAL RULES FOR NUCLEAR SHIPS

## Section 1

### GENERAL

**101** The class notation "Nuclear Powered" will be assigned in accordance with the provisions of Chapter B to all sea-going ships equipped with a nuclear reactor or reactors for main propulsion and built in accordance with, or by standards equivalent to, the relevant rules.

**102** The requirements of Chapters C to P apply as may be relevant to nuclear-powered ships, except as otherwise required by the following rules.

### HULL

#### Definitions

**103** The containment vessel is defined as the vessel containing the reactor, primary circuit and associated equipment.

**104** The reactor compartment is defined as the compartment in the ship in which the containment vessel is situated.

**105** The containment protection length is defined as the overall length of the containment vessel plus a marginal length at each end of the vessel. The margin at each end is not to be less than B/5 with a minimum of 10 feet (3 metres).

#### Method of Construction

**106** Welded construction is to be adopted for all structural material bounding the reactor compartment.

#### Quality of Material

**107** In addition to the items required by D 3104, D 3710 and D 3711, or D 4010 and D 4011 (as appropriate) and paragraph 108 (below) to be of Grade D or E steel, strength deck plating, sheerstrake, bottom plating and keel, exceeding 1·00 inch (25,5 mm.) in thickness is to be of Grade D from ·25L aft of midships to ·25L forward of midships.

**108** The material of deck, sheerstrake, side and bottom shell plating, including keel, over the containment protection length is to be of Grade E steel.

#### Longitudinal Strength

**109** The scantlings of the deck outside the line of openings and those of the side and bottom shell are to be such that the longitudinal strength (represented by the section modulus amidships of the hull girder) will exceed by 10 per cent the requirements of the Society's Rules for the class of ship.

**110** The midship thicknesses of the deck, sheerstrake, side and bottom shell plating are to extend from ·25L aft of midships to ·25L forward of midships.

**111** Continuity of longitudinal strength members is to be provided at the ends of the reactor compartment and containment protection length and rapid changes of section are to be avoided. The containment protection is to be tapered to the normal structure over the marginal length. If a reactor is in a central position in the ship and loading and discharge of fuel elements takes place through the decks or if other essential items of equipment are situated on the centre line, the structural arrangements are to provide for the effective continuity of longitudinal strength.

**112** Shielding should not encase structural members unless built up in units with overlapping or socketed joints to permit free deflection of the ship girder. Thick steel or sandwich structures should not be made an integral part of the hull structure for similar reasons, nor should similar heavy structures be erected in contact with, or adjacent to, the containment vessel unless precautions against transmission of impact loads to the containment vessel are observed.

#### Ship Motions and External Shocks

**113** Consideration should be given to the position of the reactor, associated shielding and other heavy weights with respect to the vertical and longitudinal mass centre of the ship. Reactor components and supports should be designed on a basis of a shock or impact acceleration of 3g in any direction applied through the supports and other connections to the ship's structure. In this context, reactor components are defined as all components within the reactor com-

partment above the top of the double bottom structure which are associated with the reactor and steam generators, including their supports.

**114** Arrangements for the support of long rigid items of ship's machinery should take account of the deflection of the main hull girder in service.

### Collision and Grounding Protection

**115** The structure of the ship below the reactor and at the sides in way of the containment protection length will require to be specially considered from the aspect of absorption of the energy of collision and grounding forces. The integration of the side protection into the deck structure will also require special consideration.

**116** A double bottom structure of depth not less than 6 feet (1,85 metres) is to be fitted in way of the reactor compartment and should incorporate a longitudinal system of framing in association with bottom transverses. The proposed arrangement should be submitted for special consideration. Alternative equivalent systems may be considered on merit.

### Side Framing

**117** Side shell framing and collision protection structure in way of the containment protection length will require to be specially approved.

**118** A watertight longitudinal bulkhead is required to be fitted between the containment vessel and the ship's side, not less than 5 feet (1,5 metres) from the inner line of primary shell supporting members (or inner skin if double skin construction is adopted) at the load water line, nor less than 5 feet (1,5 metres) from the containment vessel. In ships with machinery aft the minimum clearance between side shell and longitudinal bulkhead at positions below the load water line is to be determined in the design stage. This bulkhead should, wherever possible, be in line with similar longitudinal material in the half length amidships. Where this is not possible, the arrangements for continuity are to be specially approved. Resistence to collision damage is to be assessed in the design stage for each case and the position of the longitudinal bulkheads may be reviewed in accordance with the circumstances. Access to the reactor compartment is not to be effected through the longitudinal bulkhead.

**119** The framing associated with longitudinal bulkheads in way of the containment protection length will be the subject of special approval.

**120** The wing spaces abreast the reactor compartment are to be void, but water can be carried in the double bottom below the compartment.

### Cargo Hazard Protection

**121** Cargo spaces are to be isolated from the reactor compartment by a cofferdam not less than 5 feet (1,5 metres) in length. For this purpose the machinery spaces and pump rooms will be regarded as equivalent to cofferdams. The modulus of the stiffening members of the cofferdam bulkhead adjacent to the reactor compartment is to be twice that required by D 50.

### Support and Location of Containment Vessel

**122** The integration of the supporting structure of the containment vessel with the double bottom structure should be such that the bottom shell in way of the reactor compartment should be capable of sustaining comparatively severe local damage without prejudicing the support of the reactor and its relative position in the ship.

The weight of the containment vessel and its contents should not be supported directly by primary members of the ship's structure, but by an indirect flexible mounting system with basic support provided by the primary members. Indirect alternative support may also be furnished by the deck and/or transverse or longitudinal bulkheads. The secondary members of the bottom framing system should not be used as supporting members for the containment vessel unless special precautions are observed to eliminate notch effects and rapid changes of section at the ends of the reactor compartment. The structure and supports of the reactor installation are to be such that so far as practicable all items will be held in position relatively to the ship at all attitudes subject to flexural requirements.

**123** The containment vessel is not to be an integral part of the hull structure and is to be constructed in such a manner that the transmission of stresses between the hull structure and the containment vessel is reduced to a minimum.

**124** The containment vessel is to be of a form suitable for support within the hull. No part of the containment vessel should extend outside a vertical datum B/5 feet (metres) inboard of the ship's side at

the load water line nor below a datum 8 feet (2,4 metres) above the keel. The requirements of paragraph 118 must also be satisfied. Limitations on clearance between side shell and containment vessel at intermediate positions will be determined in the design stage.

### Reactor Compartment Air Test

**125** The structure of the reactor compartment is to be gas tight and air tested on completion to a pressure of 4 p.s.i. (0,28 kg. per cm.$^2$) gauge. Arrangements for the ventilation of the atmosphere in the reactor compartment are to be such that its integrity as a gas tight compartment is unimpaired (*see* paragraph 514).

### Steering Gear

**126** The ship is to be fitted with two entirely independent means of steering, each operated by power sufficient to put the rudder from hard over to hard over in 30 seconds, when the ship is going ahead at full speed. For this purpose a four ram electric hydraulic gear fitted with two independent pumps and motors with separate leads from the source of power can be accepted, provided each motor satisfies the above requirement.

An alarm system is to be fitted to give warning in the event of failure of one of the means of steering and a press-button starter for the alternative system is to be provided in the wheelhouse so that the second motor can be started immediately after the first one has failed. Alternatively, the change-over to the alternative system may be fully automatic. Particulars of the proposed system are to be submitted for approval.

The control from the bridge to the steering gear is to be in duplicate and provision is to be made at the bridge steering position for change-over to the alternative system.

## Section 2

### PRESSURE VESSELS AND COMPONENTS

**201** Pressure vessels and components for nuclear installations are to be considered in the following categories :—

#### Category 'A'

Pressure vessels and components which are :—

1. Intended to contain radioactive materials in service,

and

2. Either (i) subject to direct neutron irradiation such that the physical properties of the materials of construction will be significantly affected during the projected life of the nuclear installation,
or (ii) inaccessible for normal comprehensive periodic examination and maintenance from biological considerations of radioactivity.

#### Category 'B'

Pressure vessels and components which are :—

1. Intended to contain radioactive materials in service,

and

2. May be subject to direct neutron irradiation but not such that the physical properties of the materials of construction will be significantly affected during the projected life of the nuclear installation, but which will be accessible for normal comprehensive examination and maintenance at any selected time during the projected life of the nuclear installation.

#### Category 'C'

Pressure vessels and components which are :—

1. Not intended to contain radioactive materials in service,

and

2. May be subject to direct neutron irradiation but not such that the physical properties of the materials of construction will be significantly affected during the projected life of the nuclear installation and which will be accessible for normal comprehensive examination and maintenance at any selected time during the projected life of the nuclear installation.

#### Category 'D'

Containment vessels.

### Category 'A'

**202** The materials of construction of these vessels are to be of a readily weldable quality, of adequate corrosion resistance and chosen from types which have been proven in pressure vessel service under similar conditions from conventional aspects. Data relating to the probable behaviour of materials under irradiation should be available.

**203** Irradiation monitoring specimens representative of the materials of construction and of the welding of the vessels are to be provided. A programme of monitor specimen testing is to be drawn up covering the projected life of the nuclear installation.

**204** Pressure vessels are to be designed and constructed generally in accordance with the Rules for Welded Pressure Vessels, Class I. Alternatively they may be designed generally in accordance with B.S.S. 1500 Class I or an approved code of a recognised National Authority.

The design conditions to be adopted are as follows :—

Design pressure equal to the relief valve setting in p.s.i. (kg. per cm.$^2$) gauge plus 5 per cent with a minimum of 25 p.s.i. (1,75 kg. per cm.$^2$).

Design temperature to be the maximum coolant temperature under normal operating conditions.

**205** The effect of the following factors on stress levels must also be taken into consideration :—

(*a*) Shock and impact loading; as a design criterion, an acceleration force up to 3 g is to be assumed to act for a perceptible period in any direction (cf. paragraph 113).

(*b*) Internal and external loading applied by or through circuits, supports and other connections, and self weight.

(*c*) Temperature differentials and gradients occurring during normal operation, including start-up and shut-down.

**206** Special attention is to be given to effecting a clean design minimising stress concentrations. Reinforcement of major nozzle and other openings in the main pressure shell by the use of doubling plates is not permitted. Weldments are to be designed to permit 100 per cent radiography wherever possible.

**207** The weld procedure specification is to be prepared giving details of the proposed methods of fabrication, including all pertinent welding variables and proposed methods of non-destructive examination. The specification must also include proposals in respect of the following :—

(*a*) Weld procedure tests to prove the proposed methods.

(*b*) Welding operator tests to prove each welder's ability.

(*c*) Production tests to prove the maintenance during fabrication of the standard of welding established and approved under weld procedure tests. Such tests are to be representative of the final conditions of the welding of the completed vessels and components.

The above tests are to be carried out under the conditions obtaining during fabrication.

**208** On completion of fabrication, a hydraulic test is to be applied to a pressure 50 per cent in excess of the design pressure corrected for any increase in thickness incorporated as a corrosion allowance and for any difference in the physical properties of the vessel materials between test and design temperatures.

### Category 'B'

**209** The requirements for vessels in this category are as for Category 'A', except that paragraph 206 is not applicable and irradiation data on materials is not required.

Internal and external access for normal comprehensive periodic examination of all vessels and components which are accessible from biological considerations of radioactivity is to be provided.

**210** The secondary sides of steam generators are to be considered in this category.

**211** The pressure tightness of fuel assembly containers or coffins and associated coolant systems should also be considered in this category. Where closure of the pressure shell is effected by mechanical means, facilities are to be provided to test the integrity of the joint against leakage at any selected time.

### Categories 'A' and 'B'

**212** Vessels and components of the primary circuit are to be shop fabricated and shop tested wherever possible. The number of *in situ* closing welds must be kept to a minimum and adequate access is to be provided in each case.

**213** On completion of the installation of the primary circuit a test pressure of 1½ x Design Pressure is to be applied.

A leak test is also to be applied to the completed primary circuit for each proposed installation in a manner approved by the Society.

**214** Provisions are to be made to facilitate periodic pressure and leak testing of the primary circuit.

**215** Construction of these vessels is to be carried out in such a way that the high standard of cleanliness required can be attained.

### Category 'C'

**216** Vessels in this category are to be designed, constructed and tested in accordance with the Rules for Welded Pressure Vessels (Chapter J) or other approved code or specification.

### Category 'D'

**217** Materials for the construction of these vessels are to be of a readily weldable quality and chosen from types which have been proven in pressure vessel service under similar conditions from conventional aspects.

**218** Pressure vessels are to be designed and constructed generally in accordance with the Rules for Welded Pressure Vessels, Class I. Alternatively, they may be designed in accordance with B.S.S. 1500 Class I or an approved code of a recognised National Authority.

**219** No means of internal pressure relief are to be fitted. Pressure balancing valves are to be provided to prevent collapse through external pressure in the event of sinking.

The design conditions to be adopted are as follows :—

Design pressure (internal) is normally to be the major accident pressure in p.s.i.g. (cf. paragraph 501).

Design pressure (external) is to be 50 p.s.i. (3,5 kg. per cm.$^2$).

The allowable design stress must not exceed the lesser of the following :—

$\frac{2}{3}$ of the yield stress or the ·2 per cent proof stress.

$\frac{1}{3}$ of the ultimate tensile stress.

Temperature effects are to be considered (cf. paragraph 502).

**220** The following factors are also to be taken into consideration :—

(*a*) Shock and impact loading; as a design criterion, an acceleration force up to 3 g is to be assumed to act for a perceptible period in any direction (cf. paragraph 113).

(*b*) Transport containers used for the carriage of radioactive effluent must withstand acceleration forces up to 5 g in any direction and conform to any statutory requirements applicable.

(*c*) Internal and external loading applied from ship's motion, machinery installation and shielding.

**221** Where it is envisaged that items of equipment within the containment will be removed or replaced during the life of the installation, adequate shipping openings with mechanical closures are to be provided to avoid recourse to cutting containment after pressure testing.

**222** The number and size of all openings in the pressure shell is to be kept to a minimum.

Isolating valves are to be provided for all pipe circuits penetrating the containment vessel shell and these are to be situated in accessible locations outside, and as close as possible to, the containment vessel shell.

**223** A weld procedure specification as for category 'A' is to be provided.

**224** On completion of fabrication an internal hydraulic test to a pressure at least 25 per cent in excess of the design pressure is to be applied. In cases where consideration of all relevant factors warrant scantlings in excess of those required for considerations of pressure only, the test pressure is to be 25 per cent in excess of the design pressure corrected in respect of the increased scantlings.

**225** A leak test to enable the determination of leakage rates from the containment vessel at design pressure is to be conducted. Leakage from the containment vessel into the reactor compartment should be kept to a practical minimum. The target figure to be adopted is 1 per cent in 24 hours of the gaseous content under test of the containment vessel with all machinery installed.

**226** The design and testing of the airlock chambers associated with the containment vessel are to be in accordance with the requirements of this category.

### Pressure Relief Systems

**227** The design requirements for primary and secondary pressure relief systems are to include an agreed failure of the primary secondary boundary.

The effect of the consequent transfer of fluid from the primary to the secondary circuit or from the secondary to the primary circuit is to be assessed and included in submitted calculations relating to the size of the relief valves.

Discharge from relief valves is to be contained (cf. paragraph 513).

**228** For each pressure vessel in the primary and secondary circuits in which it is possible under any foreseeable conditions for the pressure to rise above the maximum design pressure, over-pressure relief systems are to be provided.

**229** Relief systems are to be set to operate at a pressure not exceeding the vessel design pressure.

**230** In systems where it is practicable to provide total relief capacity during the agreed credible emergency condition by fitting one safety valve only, an additional safety valve of equivalent capacity is to be fitted. In multi-valve systems, additional safety valves are to be fitted in excess of the number required to provide total relief capacity. The number of additional valves to be provided will depend on the operational reliability of the safety valve types and the number involved.

Relief systems are to be designed to provide total relief capacity during the agreed credible emergency condition with the maximum pressure accumulation of 10 per cent of the design pressure with the additional safety valves isolated.

**231** Provision is to be made to detect leakage from each safety valve in normal operation. Provision is to be made to effect isolation of each safety valve during reactor and circuit operation. The shut-off arrangements are to be interlocked to ensure that the number required to effect total relief are on line.

**232** A pressure connection is to be provided to enable testing of safety valve lift *in situ*. For pilot operated safety valves, should this entail a block valve in the pilot pressure sensing line, provision must be made to ensure that during operation all these isolating valves are in the open position.

No block valves are permitted in safety valve discharge lines.

**233** Proposed departures from the above requirements will be given special consideration.

## Section 3

### REACTOR ENGINEERING

#### General Requirements

**301** Normal reactor and main machinery control during power operation are to be effected from a central control position external to the reactor compartment. An emergency reactor shut-down position with adequate monitoring instrumentation is to be provided remote from the central control position.

**302** The entrance into the containment vessel is to be through an airlock.

**303** At least two main coolant circuits with associated heat exchangers are to be provided to each reactor and safe reactor operation is to be possible with one half of the total installed heat exchanger capacity out of action.

**304** All pumps and subsidiary circuits are to be capable of isolation.

**305** Data on the expected degree of irradiation damage to moderator and coolant is to be provided and the proposed method of monitoring and controlling such damage throughout the ship's life is to be stated.

**306** Data and, if possible, experimental evidence relating to the stability of the reactor under regular cyclic motions up to accelerations of ·45 g as may be obtained in a seaway are to be provided.

**307** Auxiliaries vital to the safe operation of the reactor are to be sited inboard of the line of the longitudinal bulkheads (cf. paragraph 118).

**308** Fire extinguishers and associated permanent pipe systems are to be installed for use in the containment vessel and reactor compartment. The fire extinguishing medium is to be $CO_2$ and the apparatus is to be capable of discharging gas in sufficient quantity to give a minimum volume of free $CO_2$ equal to 40 per cent of the gross volume of the containment vessel and 40 per cent of the net volume of the reactor compartment. Special consideration is to be given to the fire resistance of all materials used in the containment vessel and reactor compartment having regard to normal operating conditions and defuelling.

Where necessary, adequate safeguards must be provided to prevent any dangerous chemical reaction between reactor materials and air or water.

**309** The provision and location of all spare equipment for nuclear components is to be detailed.

**310** Two independent means of charging coolant into the primary system are to be provided.

### Reactor Core

**311** A specification of all materials proposed for use in the core structure is to be submitted for approval.

**312** The data and calculations utilised in the core design are to be submitted for approval.

**313** The mechanical design, dimensional integrity and manufacturing tolerances of the core structure are to be submitted for examination and approval. The possible relative movement between neutron absorber control material and the core is to be assessed.

**314** All normal and abnormal reactor transients are to be evaluated and their possible effect upon the dimensional stability and strength of the reactor core support structure is to be assessed.

**315** It is recommended that all reactor pressure vessel internals are to be capable of being dismantled and removed from the pressure vessel. Proposals are to be submitted for consideration.

**316** The core structure is to be capable of withstanding an impact shock of 3 g in any direction (cf. paragraph 113).

### Fuel Elements

**317** The physical and chemical properties of the materials proposed for use in the fuel assembly, both before and after irradiation, are to be submitted for approval.

**318** The design of the fuel assembly and the operating criteria upon which the design is based are to be submitted for examination. All possible transient conditions (cf. paragraph 314) must be examined and related to possible fuel element burn-out. Experimental evidence of the mechanical strength of the fuel assembly under such transient conditions should be provided where possible.

**319** The concentration, composition and distribution of fission products in the fuel are to be assessed at the end of the designed core life assuming a final period of 100 hours full-power operation.

**320** The evidence upon which the fuel element stability has been assessed including, where possible, previous reactor experience with the proposed fuel assembly up to the full proposed design irradiation is to be submitted for examination.

**321** The corrosion rates of the fuel assembly materials in coolant and in sea water are to be determined.

**322** The fuel assembly is to be capable of withstanding an impact shock of 3 g in any direction (cf. paragraph 113).

### Reactor Coolant Flow

**323** An analysis of the consequences of complete loss of coolant flow with and without control rod action is to be provided.

**324** An analysis of the consequences of staggered loss of coolant flow with and without control rod action is to be provided.

**325** An analysis of possible events leading to and resulting from the sudden introduction of cold coolant into the reactor core is to be provided.

**326** An analysis of the consequences of a restriction of coolant flow in a fuel assembly is to be provided.

**327** Each main coolant circuit must be provided with one pump. It is recommended that a spare pump unit be carried in the containment vessel.

**328** An analysis of the consequences of leakage of primary coolant and associated loss of pressure with and without control rod action is to be provided.

### Decay Heat Removal

**329** The arrangements to remove decay heat from the core under normal shut-down conditions are to be submitted for approval. Data, together with method of calculation, is to be provided showing the assessment of variation of decay heat with time.

**330** An emergency pump to permit circulation of primary coolant sufficient to remove decay heat from the core must be provided.

**331** In the event of loss of normal electrical power, provision is to be made to remove decay heat from the core at angles of list up to 50°.

It should be assumed that the ship lists to 20° instantaneously and that the list continues to increase at the rate of 20° per hour.

Section 4

## REACTOR CONTROL

### General Requirements

**401** The control of the reactor should be effected by individual movement of groups of control rods. Alternatively, control may be effected by movement of moderator or fuel.

**402** The mechanical design of the control arrangements and associated mechanisms and the power supply to such mechanisms are to be submitted for approval. Evidence of operational reliability and proposed cycling tests to prove reliability are to be indicated.

**403** The physical and chemical properties of materials used in the control rod and associated mechanisms are to be submitted for approval. Corrosion rates of control equipment in reactor environment and in sea water are to be determined.

**404** The control arrangements are not to move out of the core under gravity, under the force of coolant flow, shock loads or ship movement.

**405** A degree of operator adjustment of the control arrangements is to be possible. Protection against possible operator error is to be indicated.

**406** The normal full-power operating temperatures of control rods are to be determined and the maximum temperature obtaining with one control rod stuck in the core is to be determined. The effect of thermal shock on a control rod is to be investigated.

**407** The maximum insertion and withdrawal rate of any rod or group of rods is to be stated and related to possible reactor instability.

**408** The consequences of continuous rod withdrawal at start-up and full power are to be calculated.

**409** The control equipment and its associated mechanisms when supported in their environment are to be capable of withstanding an impact shock of 3 g in any direction (cf. paragraph 113).

### Reactor Shut-Down

**410** The control arrangements are to be capable of operation at all ship angles and in the event of power failure must fail safe.

**411** One control rod group should be completely withdrawn prior to reactor start-up and insertion of this group of rods under all conditions is to result in shut-down. Where control is effected by movement of moderator or fuel an equivalent safeguard is to be provided.

**412** The reactor design is to permit implementation of normal shut-down and scram action. The plant parameters and the analysis of transient conditions under which scram action will be initiated are to be submitted for approval.

**413** An alternative method of shutting down the reactor which is not affected by structural distortion of the core, e.g., chemical poisoning, is to be provided. The time required to operate the system is to be stated.

**414** The reactor must scram under the following ship conditions :—

(i) 50° list.
(ii) 10° trim.
(iii) Submerging of the centre of containment to depth of 50 feet (15 metres) below water level.

### Reactor Start Up

**415** Evidence of the validity of the proposed safe operating procedures during start-up is to be provided.

**416** The permissible temperature gradients of the primary circuit and the method proposed to pressurise the primary circuit are to be submitted for approval.

### Instrumentation

**417** Control instrumentation and supplies are to be defined so as to meet control requirements and fault conditions. The instrument response to reactor transients is to be demonstrated.

**418** All nuclear instrumentation, including health monitoring equipment, is to be described and its accuracy, reliability and range of operation demonstrated.

**419** The method and extent of duplication of essential nuclear instrumentation and supplies is to be stated.

It is required that failure of any item of equipment in any channel shall result in a non-safe indication from that channel. Provision to test each channel without loss of reactor protection is to be possible.

**420** All instrumentation related to the reactor and reactor compartment is to be described and its accuracy, reliability and range of operation demonstrated.

**421** Basic reactor safety instrumentation at the central control position and at the emergency shut-down position should be adequately shock mounted.

## Section 5

### COMPLEMENTARY INSTALLATION REQUIREMENTS

#### Major Accident

**501** A containment vessel or structure is required that encloses all primary coolant circuits and the design of this vessel is to be related to a pressure resulting from a major accident. This accident should be based on an appreciation of the particular reactor design and is to include :—

(*a*) Examination of possible nuclear transients contributing to the heat content of the primary circuit.

(*b*) Assumption of complete severance of main coolant pipe or equivalent failure occurring at working pressure and resulting in discharge of primary coolant into the containment.

(*c*) Assumption that failure of the secondary circuit discharges a proportion of the secondary fluid into the containment.

(*d*) Consequent exothermic chemical reaction which might result from core melt-down.

**502** A pressure/time curve and temperature/time curve covering the first 24 hours after the accident are to be submitted for examination, together with relevant calculations. In addition, the provision to prevent molten fuel penetrating the containment is to be indicated.

**503** An assessment is to be made of possible damage to the containment vessel by missiles produced as a consequence of a component failure inside the containment.

**504** A summary of credible accidents covering each particular installation and indicating the degree of hazard involved is to be submitted for consideration.

#### Shielding

**505** Radiation contours in and around the hull, together with method of determination, are to be submitted for approval. Such contours should be determined for full-power operation, shut-down, dry docking, defuelling and after the major accident which invokes the use of containment.

**506** In general, designers should work to the recommendations of the International Commission of Radiological Protection so that crews do not receive an integrated radiation dose in excess of 5 rem per year. When the integrated dose is calculated the possible need for maintenance work in high irradiation areas must be considered and it is recommended that 50 per cent of the total dose be reserved for this purpose.

**507** The design of primary and secondary shielding, together with their siting and method of securing in the hull structure, are to be submitted for approval. Where necessary, arrangements for shield cooling and ventilation are to be indicated. Adequate periodic examination of the parent structure must be possible.

#### Defuelling and Refuelling

**508** Prior to opening the reactor pressure vessel all available reactor control must be inserted into the core.

**509** Removal of a fuel assembly from the core into a coffin is to take place in such a manner that there will be no hazardous release of fission products to environment. The reactor core is to be in a containment of agreed design at all times. In addition, irradiation hazards to personnel are to be limited and should not exceed the maximum dose rates as laid down by an accepted international body.

**510** The fuel coffin is to be capable of being cooled and the consequences of failure of cooling are to be examined. The method of cooling and design of the coolant circuit are to be submitted for approval.

**511** The design of the fuel coffin is to be related to an approved maximum pressure and temperature to which the coffin is to be subjected, and the leak rate of the coffin under such conditions is not to exceed 0·1 per cent per 24 hours of the gaseous volume of the coffin loaded with a fuel assembly.

**Effluent Disposal**

**512** The facilities provided on board for the storage of irradiated material obtained from the reactor systems and the method proposed for the removal and the subsequent storage ashore is to be submitted for approval.

**513** In general, containment of all solid and liquid effluents is required and the design of equipment used to effect such containment for a period of three months full-power operation and to permit of its controlled discharge is to be submitted for approval.

Temporary storage and controlled discharge of inert gaseous effluent is acceptable, subject to meeting national and international requirements.

Adequate monitoring devices for solid, liquid and gaseous effluent must be provided in all instances.

**514** The designs and proposed method of operation of air circulating, air conditioning or air purging equipment in the containment vessel and in the reactor compartment are to be submitted for approval. The capacity of the equipment is to be related to the net volumes of the compartments and is to permit complete processing of such volumes in 30 minutes. All air before discharge is to be passed through a clean-up unit to remove fission products.

**Electrical Installations**

**515** Electrical installations are to be in accordance with Chapter L or M as appropriate and, in addition, with the following rules.

**516** Limits of voltage and/or frequency between which equipment will operate satisfactorily are to be stated.

**517** The electrical installation is to be such that failure of any component (e.g., generators, motors, bus-bars, protective devices or cables) does not interrupt the supply to services essential for the safety of the ship.

**518** Emergency supplies in the event of reactor shut-down and/or failure of main supplies must be stated.

**Secondary Circuit**

**519** Secondary circuit equipment, other than primary and secondary heat exchangers, is to conform with the Society's Rule requirements. Power must be available to permit normal manœuvring of the ship and the flexibility of the system is to be shown to accommodate all variations in main engine demand.

The reactor transients under such conditions are to be submitted for examination.

**Emergency Power**

**520** Unless two or more reactors capable of independent operation are fitted, an independent power supply separate from and independent of the nuclear machinery must be available. The power output of such machinery must maintain a ship's speed of about six knots.

A range of 1,000 miles (1,600 kilometres) is required.

**Cleanliness**

**521** The Society requires a high standard of cleanliness to be maintained during construction of reactor components and their assembly into a hull. The methods and techniques required to obtain such a standard are to be submitted for approval.

## Section 6

### SURVEY AND MAINTENANCE

**601** All proposed procedures for normal and emergency operation, servicing and maintenance are to be included in the Operations Manual which is to be submitted for examination.

**602** Hull and main machinery shall be subject to normal survey requirements.

**603** All machinery used directly in conjunction with the reactor shall normally be subject to survey at two-yearly intervals.

**604** The survey requirements for Category 'A' pressure vessels and components will be given special consideration for each installation proposed.

**605** The main steam generators and associated components in the containment which fall in Categories 'B' and 'C' (paragraph 201), together with supports and seatings, shall be subject to survey at two-yearly intervals or at each period of refuelling whichever is shorter.

**606** Category 'D' vessels are to be subject to an air test to the design pressure at four-yearly intervals and whenever a modification or repair to the pressure envelope is made.

**607** A leak test on Category 'D' vessels is to be carried out at two-yearly intervals. The leak test is to be carried out at 50 per cent of the major accident pressure or at a lower agreed figure, provided a leak rate/pressure curve has been determined.

**608** Any supports and double bottom structure external to and in way of the containment vessel shall be subject to survey at two-yearly intervals.

**609** Primary and secondary shielding, together with associated parent structure shall be subject to survey at two-yearly intervals.

**610** The design of the reactor installation should permit maintenance work, servicing and inspection to be carried out without excessive exposure of personnel to radiation hazards, which should not exceed permissible dose rates as laid down by international agreement.

*June, 1960*

# R (D)—GUIDANCE NOTES ON METAL PIPES FOR WATER SERVICES

## Section 1

### PIPES FOR SEA WATER SERVICES

#### Types of Corrosion

**101** The following types of accelerated corrosion have arisen with piping materials for sea water services:—

(a) Galvanic corrosion of the less noble metal where dissimilar metals were in association.

(b) Pitting corrosion, the main causes being local attack by deposits or transfer of small pieces of metal such as weld spatter, sulphides in polluted esturine waters, gassing in hot tubes of coolers, fouling and cathodic films in the bores of pipes as a result of incorrect methods of manufacture or fabrication.

(c) Corrosion-erosion where water speeds are excessive for particular metals. This may be particularly severe where turbulence occurs, e.g. protrusions in pipe bores, tight bends.

(d) Dezincification of some types of brasses including "manganese bronze".

(e) Stress corrosion cracking of copper-zinc alloys.

(f) Severe local corrosion due to sulphur and/or sulphide contamination of pipes.

(g) Cavitation erosion where water speeds are very high.

(h) Rusting of steel pipes when no protection has been applied or where protection has proved insufficient due to manufacturing fault or damage.

**102** Metals differ in their resistance to these various forms of corrosion but even where corrosion resistant types have been used, inadequate attention to design detail or workmanship has caused failures. The following are recommendations for the selection of materials and practices.

#### Materials for Pipes and Flanges

**103** Steel pipes should be protected against corrosion. Galvanising of the bores is the most common practice and is recommended as the minimum protection. All steel pipes of bilge and ballast lines should be galvanised.

Galvanised steel pipes should not be used for continuous service where water speeds exceed about 10 ft./sec. (3 metres/second).

The life of a galvanised coating depends on its thickness which to some degree is controlled by pipe thickness. In some cases, it may be advisable to use a pipe of heavier gauge. Welds should be free from lack of fusion and crevices. Where possible, the surfaces should be dressed to remove slag and spatter and, where possible, this should be done before galvanising. Preferably the coating should be continuous round the ends of the pipes and on the faces of flanges.

**104** Rubber-lined steel pipes can give excellent service. The lining is resistant to all forms of corrosion and is particularly effective against scouring by sand. A good bond between the rubber lining and the steel of the pipe is essential. Preferably the rubber lining should be carried round the ends of the pipe and over the faces of the flanges to act as jointing material. There should be no discontinuities or pinholes in the lining, through which corrosion can occur and lift the coating. For these reasons rubber linings should be applied by specialist firms and care taken to avoid damage to finished coatings.

The foregoing comments also apply to plastic-lined pipes. Pipes with stoved coatings are also efficient, but care should be taken to avoid mechanical damage to flanges.

Coatings of the above types should be applied on completion of fabrication, i.e. forming and welding of steel pipes.

**105** Copper pipes are particularly susceptible to perforation by corrosion-erosion. These pipes have given the greatest trouble in sea water systems. In some cases copper pipes have been replaced by galvanised steel pipes which have given superior performance.

The cause of the failures of copper pipes has been due mainly to the continuation of an established practice over a period when water speeds have increased appreciably. Low water speeds should be used with copper pipes and excessive local turbulence should be avoided.

**106** Certain copper alloys have enhanced resistance to impingement attack and can be used where water speeds are higher than can be tolerated by copper. These alloys are as follows:—

Copper—30% Nickel—0·8% Iron Alloy.
Copper—10% Nickel—2% Iron Alloy.
Aluminium Brass.
Admiralty Brass.
Copper—5% Nickel—Iron Alloy.

In general, aluminium brass pipes and tubes give reliable service with reasonably clean sea water. For service with polluted river or harbour waters copper-nickel-iron alloy pipes and tubes are preferable. The nickel content of the alloy for these conditions should not be less than 10%. New copper alloy pipes should not be exposed initially to polluted water. Reasonably clean sea water should be used first in order that the metals can develop protective surface films.

**107** Austenitic types of stainless steel are not recommended as they are prone to deterioration when in contact with polluted waters.

**108** Where pipes are exposed to sea water on both external and internal surfaces, flanges should be made preferably of the same material. When sea water is confined to the bores of pipes the material of the flange is of less importance from the point of view of corrosion. However, flanges of the same or a less noble metal than that of the pipe, are recommended. Gunmetal flanges on aluminium brass pipes are an exception to this recommendation. Brass for flanges should be of the type containing 1·0% to 2·0% tin to minimise dezincification.

**109** Fixed or loose type flanges may be used. The fixed flanges should be attached to the pipes by fillet welds or capillary silver-brazed joints as appropriate. Where welding is used, the fillet weld at the back should be a strength weld and that in the face a seal weld.

Where silver-brazing is used, strength should be obtained by means of the bond in a capillary space over the whole area of the mating surfaces. A fillet braze at the back of the flange or at the face is undesirable.

A combination of a silver-brazed joint at the front face and a normal brazed joint at the back face has given satisfactory service when the bore surface only was exposed to sea water.

**110** With copper-nickel-iron alloy pipes, flanges of a similar type of alloy or of mild steel may be attached by argon arc welding. A mild steel flange should not be used when it will be in contact with sea water.

Copper, brass, bronze, gunmetal or copper-nickel-iron alloy flanges may be capillary silver-brazed to copper, aluminium brass or copper-nickel alloy pipes. "Bronze welding" should not be used. Brazing of inhibited alpha brass flanges to copper pipes using rods of a 92·75% copper–7·25% phosphorus alloy has given satisfactory service. The alloy used for silver-brazing should contain not less than 49% silver.

Mild steel flanges should be fusion welded or flash butt welded to mild steel pipes.

**111** Alpha brasses must be properly inhibited against dezincification by suitable additions to the composition. Alpha-Beta brasses or those containing less than 70% copper should not be used for pipes and fittings.

**Design Considerations**

**112** In sea water, galvanic corrosion may cause premature failure of a component when it is in contact with one of a more noble metal. For guidance, the Table gives the galvanic series for common metals in sea water. A metal in direct contact with one lower in the list may suffer accelerated corrosion in sea water.

**TABLE 1**

GALVANIC SERIES IN SEAWATER

| |
|---|
| Zinc |
| Aluminium |
| Carbon Steel |
| Cast Iron |
| Lead-Tin Solders |
| Lead |
| Brasses |
| Copper |
| Phosphor Bronze |
| Gunmetal |
| Copper-Nickel-Iron Alloys |
| Aluminium Bronze |
| Monel Metal |

Where components are made from different metals, preferential corrosion of the less noble metal may be minimised by the introduction of a sacrificial anode. This is made of a metal which is higher in the Table than either of the working metals. Where a sacrificial anode is used to provide local protection, there should be an efficient electrical bond between it and the metal which it is to protect.

**113** Water speeds should be carefully assessed at the design stage and the materials of pipes, valves, etc., selected to suit the particular conditions.

**114** Attention should be given to the design, fabrication and installation of systems to ensure streamlined flow. In particular, abrupt changes in the direction of flow, protrusions into bores of pipes and other restrictions of flow should be avoided.

Pipe bores should be smooth and clean. Any carbonaceous films or deposits formed on the bore surfaces of non-ferrous pipes during bending processes should be carefully removed. Jointing should be flush with the bore surfaces of the pipes. Branches preferably should be set at a shallow angle to the line of the main piping, the junction should be smooth and the branch should not protrude into the bore of the main pipe. Tight bends should be avoided. The bore surfaces should be smooth at these positions and free from puckering.

**115** Very low water speeds and stagnant zones should be avoided. Systems should not be left idle for long periods especially where the water may be polluted.

**116** Strainers should be provided at the inlets to sea water systems.

**117** Non-ferrous pipes which are fairly heavily cold worked during fabrication should be annealed or stress relief heat treated before they are put into service. Finished aluminium or Admiralty brass pipes, in particular, should not be overstrained to facilitate alignment and tight joints.

## Section 2

### PIPES FOR FRESH WATER SERVICES

**201** The corrosive conditions in fresh water systems are less severe than in sea water systems and generally mild steel or copper pipes are satisfactory for service in fresh water applications.

**202** Mild steel pipes should not be left idle for long periods if the water has a low salt content. This low salinity and the limited supply of oxygen promote the formation of black iron oxide on the bores of the pipes which gives rise to severe corrosion of the pipes. Where stagnant conditions are unavoidable steel pipes should be galvanised or pipes of suitable non-ferrous material should be used. Hot fresh water may promote corrosion of mild steel pipe unless the hardness and pH of the water are controlled.

**203** Copper alloy pipes should be treated by scouring or other means to remove any harmful cathodic films from the bores before pipes and tubes are despatched from the Makers' Works.

**204** Brass fittings and flanges in contact with water should be made of an alpha brass which is inhibited against dezincification.

**205** Aluminium brass pipes and fittings are not recommended for fresh water services as, under certain circumstances (not yet completely defined), premature failure by pitting and/or cracking can occur.

*21st May, 1964*

# R (E)—GUIDANCE NOTES ON TORSIONAL VIBRATION STRESSES AND CRITICAL SPEEDS FOR MAIN AND AUXILIARY OIL ENGINES

## Section 1

### GENERAL

**101** In oil engine installations, it is desirable that, for smooth running, operating speeds should be clear of critical speeds. The stress limits given in the following paragraphs, therefore, are not to be viewed as design values but rather as limiting values where critical speeds cannot reasonably be avoided. The stresses are nominal values based on the plain section of the shafting excluding stress raisers.

Between 90 and 100 per cent of the maximum speed, the stress limits apply to the sum of the vibratory stress due to any resonant order and stresses due to the dynamically magnified portions only of the flanks of other significant orders (i.e. subtracting the stresses due to the exciting torques).

Where critical speeds are found by calculation to show stresses approaching the limits, torsiograph records may be required. In practice, differences between calculated stresses and stresses measured by torsiograph or equivalent are frequently found. Where such differences arise, the stress limits are to be applied to the measured stresses.

The stress limits are applicable to steel shafts having a tensile strength of 28 to 33 tons/sq. in. (44 to 52 kg. per sq. mm.) For shafts of high tensile steel or other material, the stress limits will be subject to special consideration.

Where the scantlings of crank shafts, webs, couplings, coupling bolts and straight shafting are greater than required by the Rules, higher vibratory stress limits may be considered.

**Engine Speed R.P.M.**

**102** Maximum speed $N_S$ may be defined as the maximum revolutions per minute for which the engines are classed in continuous operation.

When submitting particulars, the "tick over" or idling R.P.M. should be indicated.

For trawler installations, the range of revolutions used during trawling should also be stated and should be maintained clear of critical speeds so far as practicable.

**Governor Control**

**103** For closely governed installations, the application of formulæ (4) and (8) may be restricted to revolutions 5 per cent higher than the governor control limit, with a minimum of $1{\cdot}10\ N_S$, provided such limit be demonstrated during engine trials.

**"Barred" Speed Ranges**

**104** Where restricted speed ranges are imposed as a condition of approval, a notice board is to be displayed at the control stations stating that continuous operation should be avoided between the limits indicated by formulæ (2) and (6), and the tachometers marked accordingly. In such cases the tachometer accuracy should be checked against the counter readings, or by equivalent means, in the presence of the Surveyors to verify that it reads correctly within $\pm 2$ per cent in way of the restricted range of revolutions.

Where vibration stresses due to criticals below $0{\cdot}8\ N_S$ marginally exceed the limiting stress for continuous operation, or where the critical speeds are sharply tuned, the range of revolutions restricted for continuous operation may be reduced.

Where such vibration stresses approach the limiting values $f_t$ given in formulæ (3) and (7) the range of revolutions restricted for continuous operation may be extended, and the notice board should indicate that this range must be passed through rapidly.

In cases where the resonance curve of a critical speed has been derived from torsiograph measurements, the range of revolutions to be avoided for continuous running may be taken as that over which the measured vibration stresses are in excess of the limiting stresses for continuous operation, having regard to the tachometer accuracy.

**Excessive Vibration Stresses**

**105** In cases where vibration stresses exceed the limiting values, the dynamic system should be re-designed, or damping or detuning arrangements provided to remove the critical speed from the operating range or to reduce the magnitude of the vibration stress.

It is preferable to avoid the use of dampers or detuners to control criticals within the range between $0{\cdot}85$ and $1{\cdot}05\ N_S$, but if fitted they should be of a type which makes adequate provision for dissipation of heat and contain no mechanical parts subject to deterioration in service.

Where dampers or flexible couplings are fitted, it may be required that torsiograph records be taken to verify their efficacy.

**Gear Hammer**

**106** In installations having reversing and/or reduction gearing, or geared scavenge blowers, etc., where the vibratory torques at the gears exceed the mean transmission

torques at the criticals considered, it may be necessary to impose a restricted range of revolutions in way of each critical speed at which gear hammer occurs.

Further, in the event of gear hammer being detected at speeds other than the calculated critical speeds, torsiograph records may be required to confirm the calculated natural frequencies.

In all cases where there is a possibility of gear hammer, the backlash in the gears should be kept to a minimum.

At critical speeds near the maximum speed the vibratory torque should not, in general, exceed one-third of the full transmission torque. In cases where the proposed loading on the gear teeth is less than the maximum allowable special consideration will be given to the acceptance of additional vibratory loading on the gears.

**Screwshafts**

**107** The stress limits for screwshafts apply to fully protected shafts having a continuous liner with efficient sealing arrangements against corrosion of the shaft by sea water, and to shafts without liner which are oil lubricated and which are fitted with an approved type of oil gland.

In other cases special consideration will be necessary.

The limits are intended to apply to the minimum section of the shaft between the forward end of the propeller boss and the forward stern gland.

**Intermediate Shafts**

**108** The stress limits for intermediate shafts apply to shafts having integral flanges with Rule fillet radii.

Where loose couplings are employed, the vibration stresses in the shaft in way of the coupling should be limited to 75 per cent of these values.

**Definition of Symbols**

**109** In the formulæ for determining vibration stresses, the symbols used are as follows:—

$N$ = engine speed R.P.M.

$N_S$ = maximum engine speed R.P.M.

$N_c$ = critical speed R.P.M.

$r$ = ratio $N/N_S$ or $N_c/N_S$ whichever is applicable,

$d$ = minimum shaft diameter considered, in inches or millimetres,

$f_c$ = maximum value of the vibration stress for continuous running at or below maximum speed, in lb. per sq. inch or kg. per sq. cm.

$f_t$ = maximum value of vibration stress due to criticals below $0{\cdot}8\ N_S$ necessitating restricted ranges, in lb. per sq. inch or kg. per sq. cm.

$f$ = maximum value of the vibration stress above maximum speed, in lb. per sq. in. or kg. per sq. cm.

**Propelling Machinery—Vibration Stress Limits**

**Crank and Screw Shafts**

**110** Where the critical occurs at or below the maximum R.P.M., vibration stresses not exceeding values given by the following formula are considered satisfactory for continous running, viz:—

$$f_c = \pm(4500-80d)\ (1{\cdot}6-r^2) \quad \ldots\ldots(1)$$

or in metric units

$$f_c = \pm(315-0{,}22d)\ (1{,}6-r^2)$$

Where the vibration stresses exceed the limiting values for continuous running as given by formula (1) a notice board should be fitted at control stations stating that the engine should not be run continuously between the following speed limits, above and below the critical speed, and the engine tachometers should be marked correspondingly, viz:—

Range of engine R.P.M. to be avoided:—

$$\text{From } \frac{16\ N_c}{(18-r)} \text{ to } \frac{(18-r)\ N_c}{16} \text{ inclusive} \quad \ldots\ldots(2)$$

The maximum values of the vibration stresses due to such criticals should not exceed those given by the following formula, viz:—

$$f_t = 2\ f_c \quad \ldots\ldots(3)$$

Criticals should be arranged sufficiently removed from the maximum R.P.M. to ensure that, in general, at $r = 0{\cdot}8$ the stress due to the upper flank does not exceed $f_c$ (formula (1)).

Where the critical occurs above the maximum R.P.M., the vibration stresses should not increase beyond values given by the following formula at revolutions up to 1·16 times the maximum R.P.M., viz:—

$$f = \pm\ (2700-48d)\left(1 + 5\ \sqrt{r-1}\right) \quad \ldots\ldots(4)$$

or in metric units

$$f = \pm\ (190-0{,}13d)\left(1 + 5\ \sqrt{r-1}\right)$$

**Intermediate and Thrust Shafts**

**111** Where the critical occurs at or below the maximum R.P.M., vibration stresses not exceeding the values given by the following formula are considered satisfactory for continuous running, viz:—

$$f_c = \pm\ (7600-80d)\ (1{\cdot}44-r^2) \quad \ldots\ldots(5)$$

or in metric units

$$f_c = \pm\ (535-0{,}22d)\ (1{,}44-r^2)$$

Where vibration stresses exceed the limiting values for continuous running as given by formula (5), a notice board should be fitted at control stations stating that the engine is not to be run continuously between the following speed limits, above and below the critical speed, and the engine tachometers should be marked correspondingly, viz:—

Range of engine R.P.M. to be avoided:—

$$\text{From } \frac{16\ N_c}{(18-r)} \text{ to } \frac{(18-r)\ N_c}{16} \text{ inclusive} \quad \ldots\ldots(6)$$

The maximum values of the vibration stresses due to such criticals should not exceed those given by the following formula, viz:—

$$f_t = 1{\cdot}7\ f_c \quad \ldots\ldots(7)$$

Criticals should be arranged sufficiently removed from the maximum R.P.M. to ensure that, in general, at $r = 0{\cdot}8$ the stress due to the upper flank does not exceed $f_c$ (formula (5)).

Where the critical occurs above the maximum R.P.M., the vibration stresses should not increase beyond values given by the following formula at revolutions up to 1·16 times the maximum R.P.M., viz:—

$$f = \pm\ (3340-35d)\left(1+5\sqrt{r-1}\right) \quad \ldots\ldots(8)$$

or in metric units

$$f = \pm\ (235-0{,}097d)\left(1+5\sqrt{r-1}\right)$$

**Auxiliary Machinery**

**112** The following notes are applicable to oil engines developing 150 b.h.p. or 100 kW. and over, driving auxiliary machinery used for essential services.

The dynamic system comprising engine and driven machinery should be so designed that vibration stresses in the crankshafts and transmission shafting resulting from critical speeds do not exceed values given by the following formula within speed limits of ·95 and $1{\cdot}10N_s$, $N_s$ being the full load R.P.M., viz:—

$$f_c = \pm\ (3000-50d) \quad \ldots\ldots(9)$$

or in metric units

$$f_c = \pm\ (212-0{,}14d)$$

Vibration stresses in the crankshaft and transmission shafting due to critical speeds which have to be passed through in starting and stopping should not exceed values given by the following formula, viz:—

$$f_t = 5{\cdot}5\ f_c \quad \ldots\ldots(10)$$

It is also recommended that the vibration torques applied to generator armatures should be reduced to the lowest possible value and, in any case, should be limited to not more than twice full load engine torque over the range ·95 and $1{\cdot}10\ N_s$ and not more than six times full load engine torque in passing through criticals below $0{\cdot}95\ N_s$. In the former case the vibration torque should be taken as the sum of the torques due to any resonant order and the dynamically magnified portions of the flanks of other significant orders. These recommendations are designed to protect the armature structure from excessive inertia torques.

In cases where vibration stresses or torques exceed the limiting values, the conditions stated under para. 105 are generally applicable, except that dampers and detuners should preferably not be used to control critical speeds occurring within the range of speeds between ·95 and $1{\cdot}10\ N_s$ inclusive.

**113** In the case of A.C. generators vibration amplitudes on the rotor should not exceed ± 2·5 electrical degrees at the full load speed.

Care should be taken to ensure that the natural frequency of the complete set is sufficiently removed from the firing impulse frequency at the full load speed, particularly where flexible couplings are interposed between the engine and generator as, otherwise, excessive amplitudes could arise under such conditions.

*For graphs showing permissible vibration stresses for propelling machinery, see pages* 558 *and* 559.

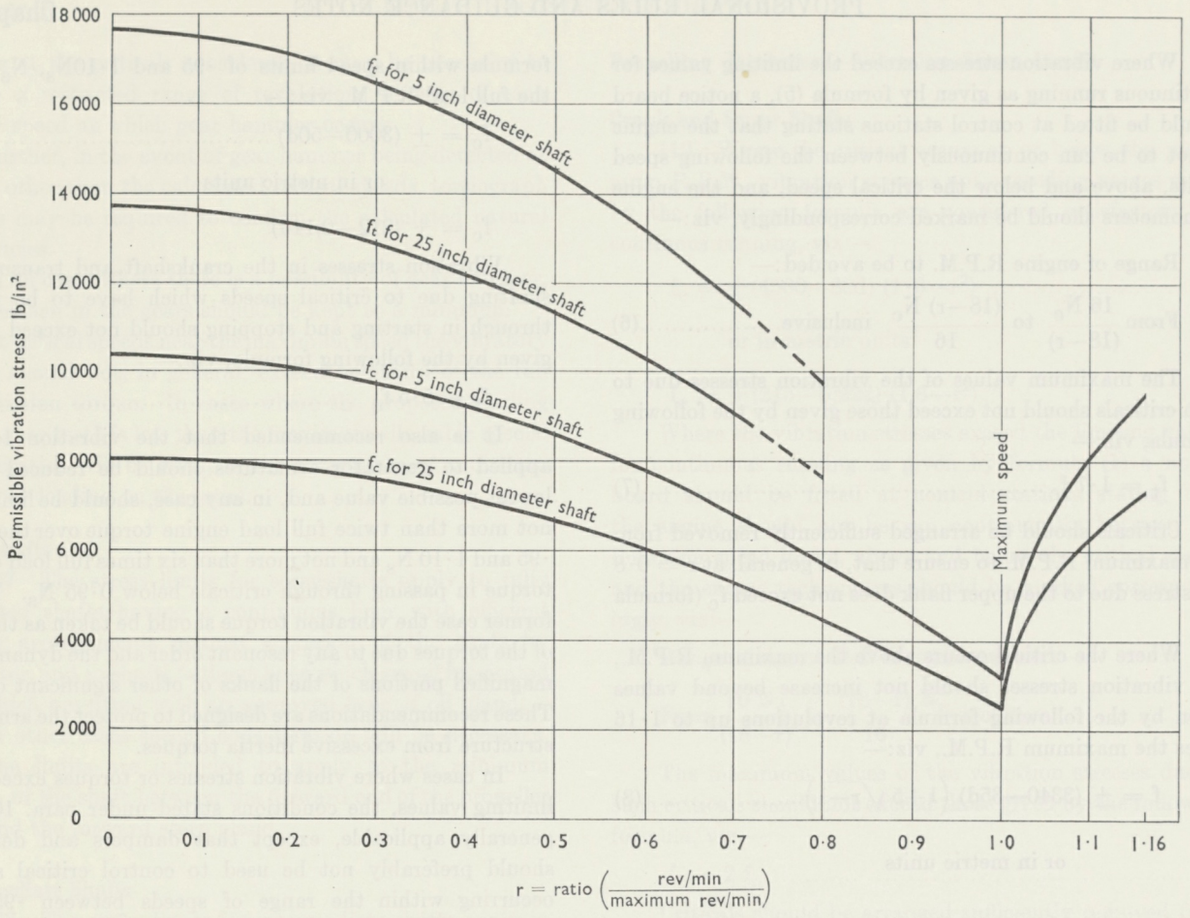
*21st May, 1964*

By Order of the Committee,

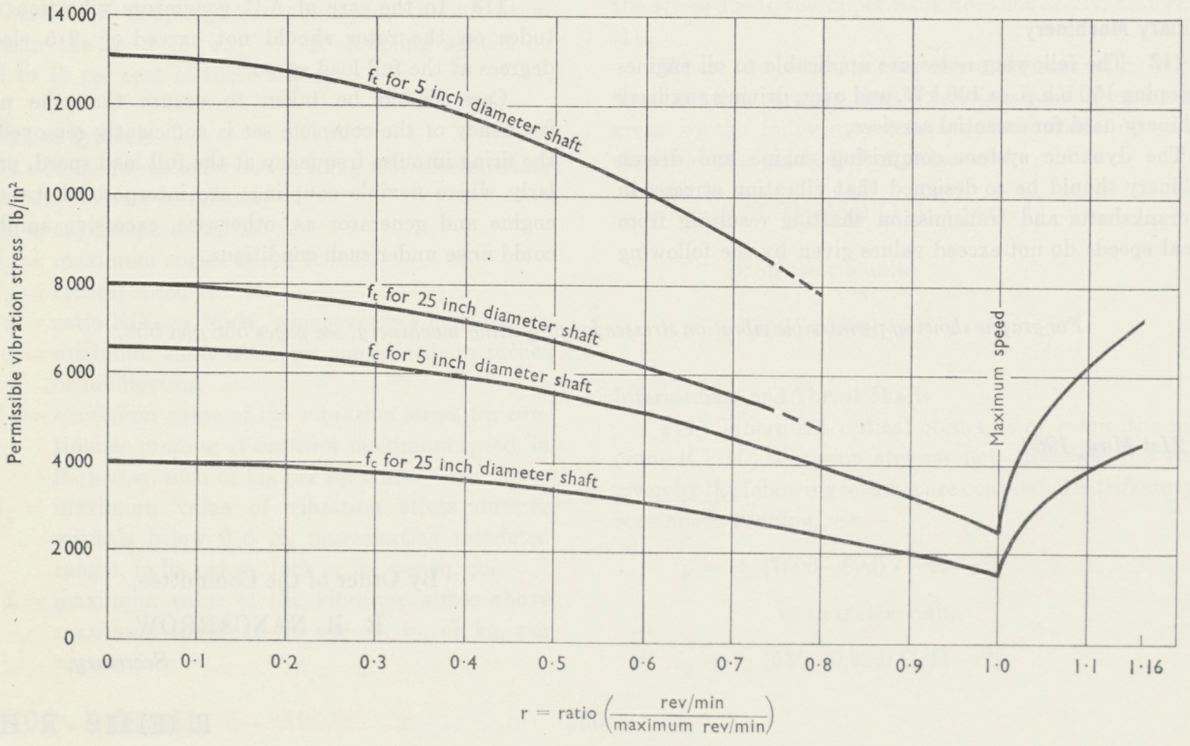
R. B. NANCARROW,

*Secretary.*

INTERMEDIATE & THRUST SHAFTS

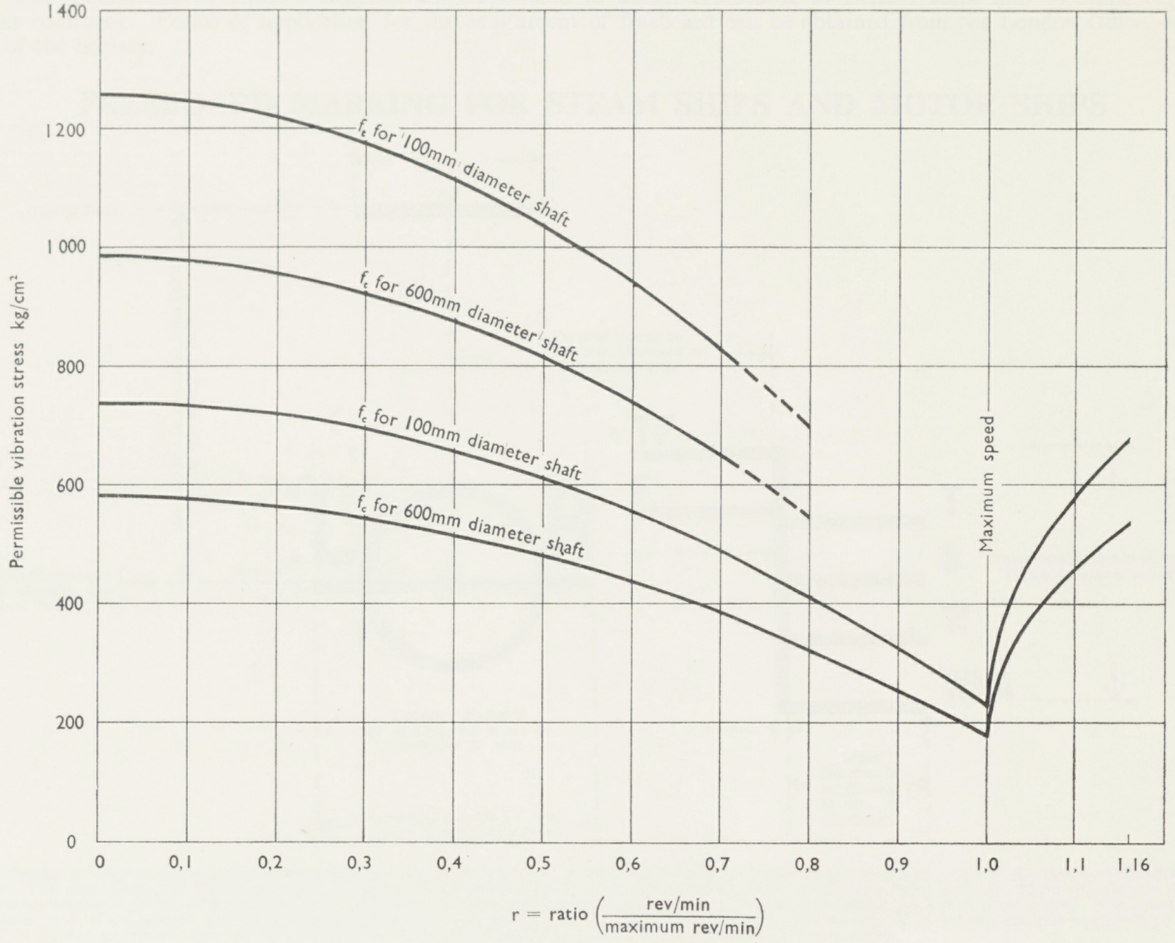



CRANKSHAFTS & SCREWSHAFTS

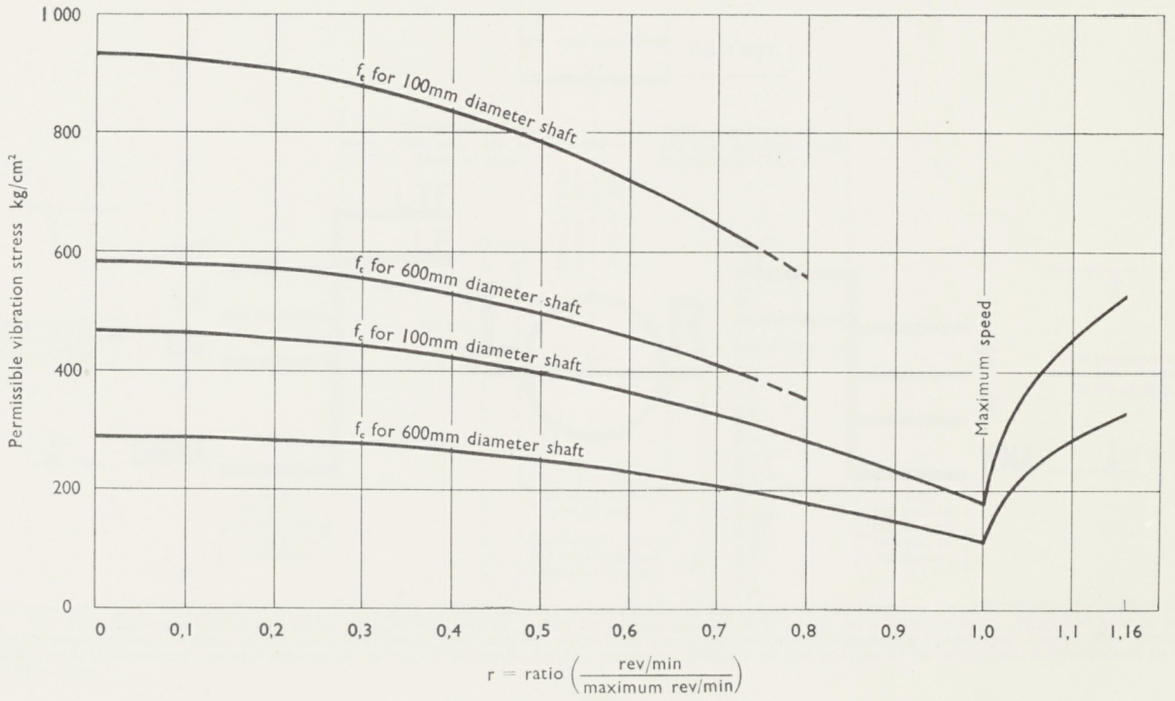



Permissible Vibration Stresses for Propelling Machinery. (British Units)

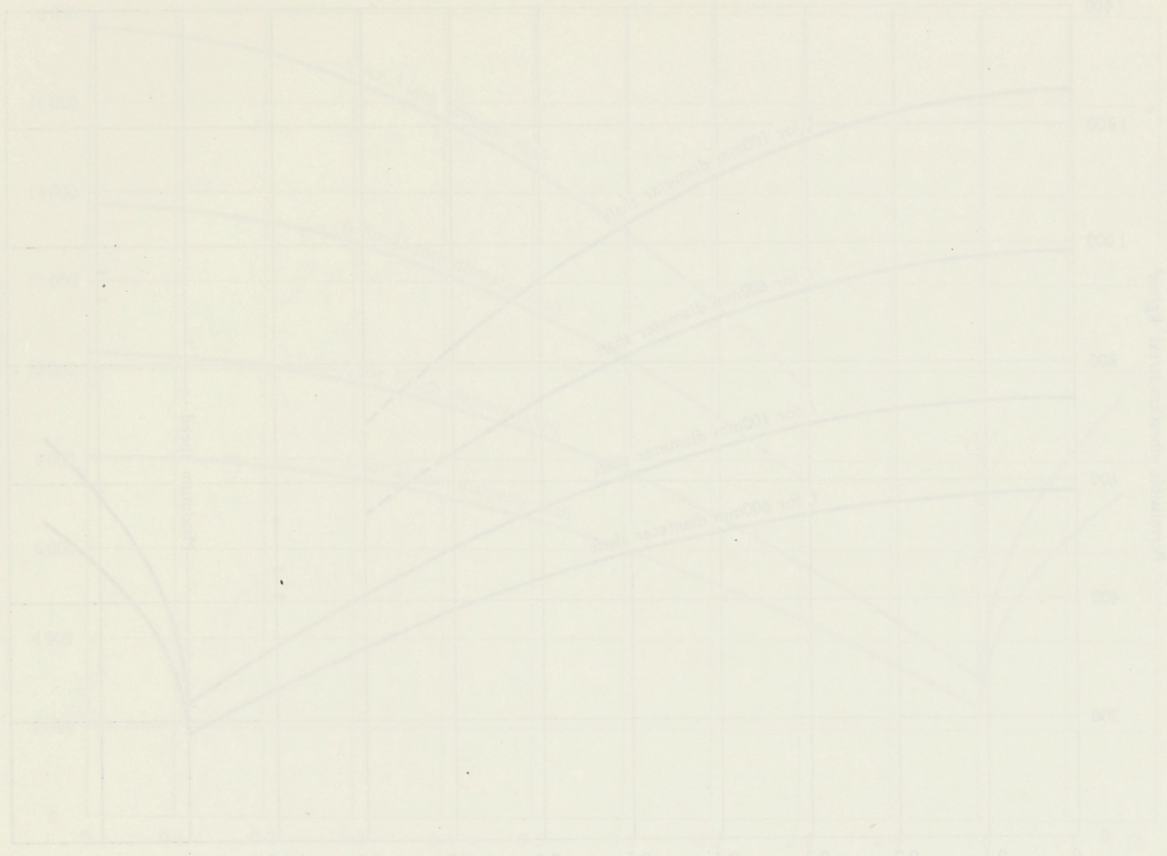
INTERMEDIATE & THRUST SHAFTS




CRANKSHAFTS & SCREWSHAFTS



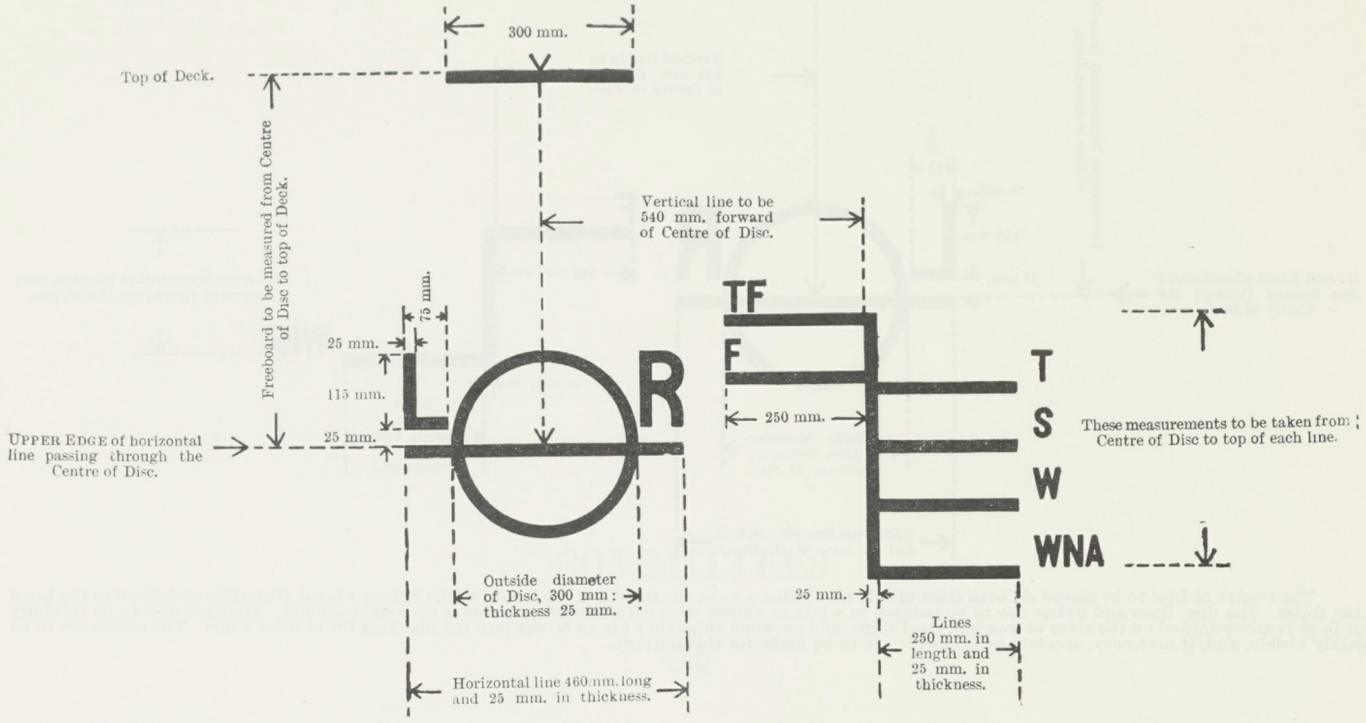

Permissible Vibration Stresses for Propelling Machinery. (Metric Units)



# ASSIGNMENT OF FREEBOARD

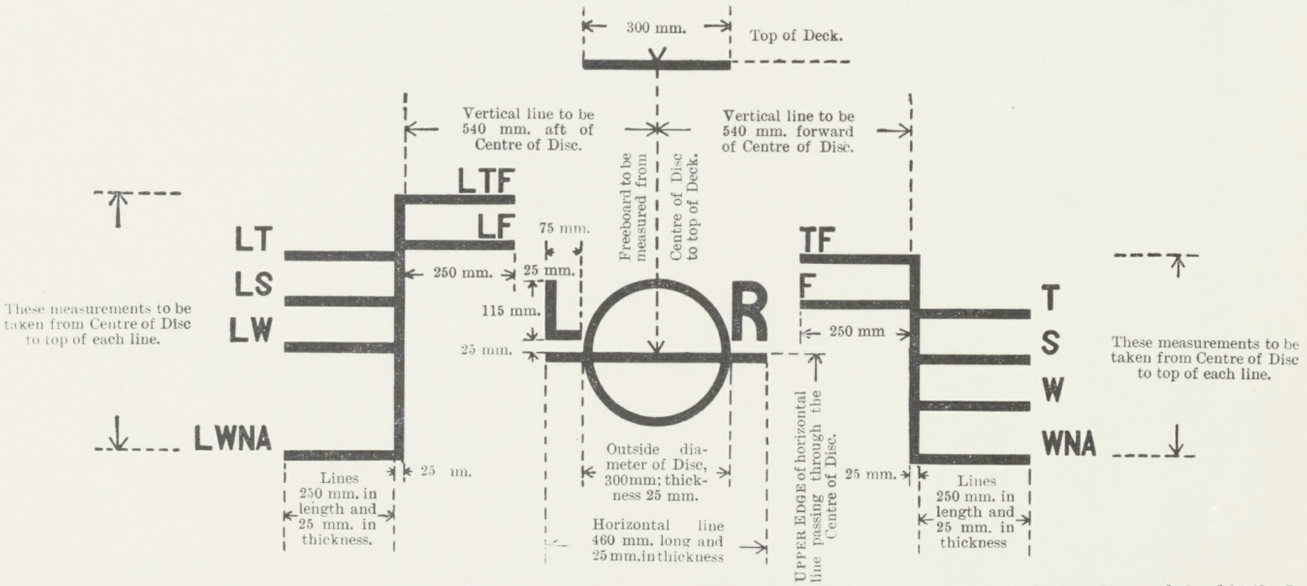
The Committee of Lloyd's Register are empowered to assign freeboards to British ships and to ships registered in other countries. Forms of application for the assignment of freeboard can be obtained from the London Office, or other offices of the Society.

## FREEBOARD MARKING FOR STEAM SHIPS AND MOTOR SHIPS




The Centre of Disc to be placed on both sides of ship amidships, *i.e.*, at the middle of the length of the Summer Load Waterline as defined in the Load Line Rules. The disc, lines and letters are to be painted in white or yellow on a dark ground or in black on a light ground. They are also to be carefully cut in or centre-punched on the sides of iron and steel ships, and on wood ships they are to be cut into the planking for at least 3 mm. The marks are to be plainly visible and, if necessary, special arrangements are to be made for this purpose. Ships over 100 metres 50 in length are not required to be marked with the W.N.A. line provided they are not tankers or ships of special type having similarly reduced freeboards.

## FREEBOARD MARKING FOR SHIPS CARRYING TIMBER DECK CARGOES

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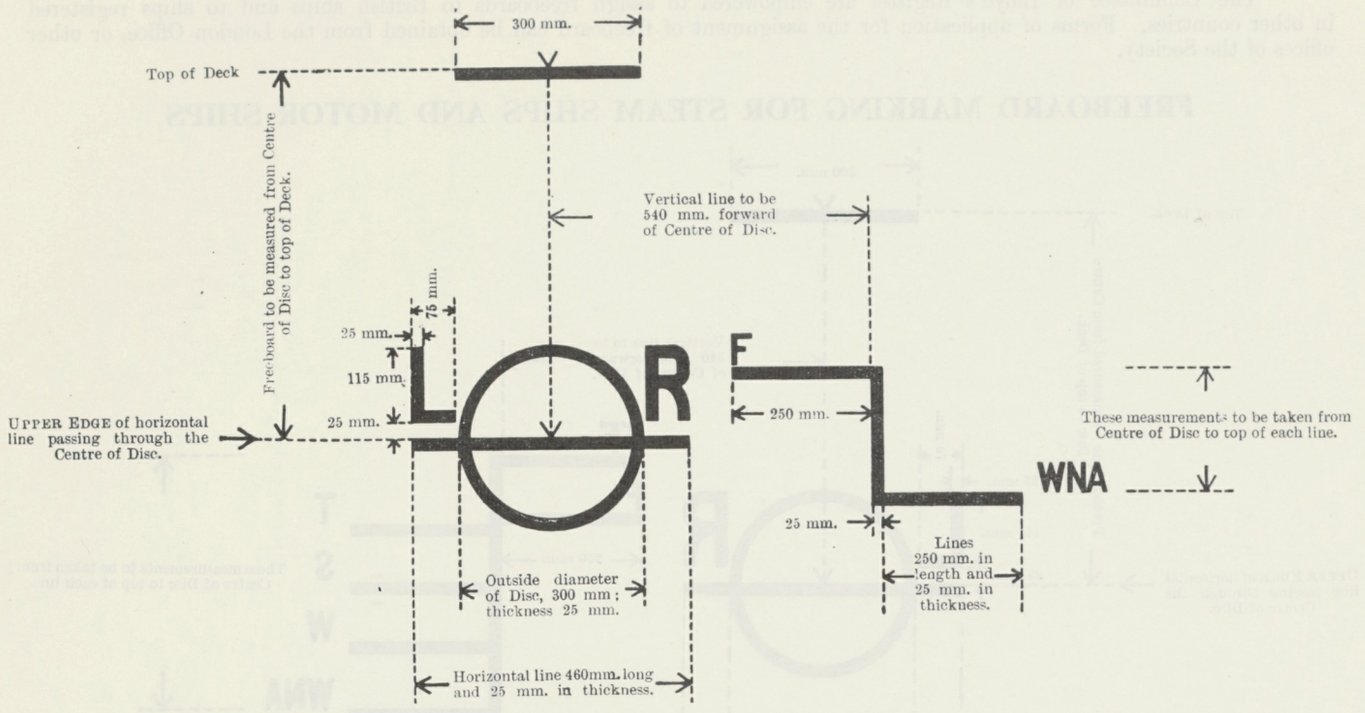


The Centre of Disc to be placed on both sides of ship amidships, *i.e.*, at the middle of the length of the Summer Load Waterline as defined in the Load Line Rules. The disc, lines and letters are to be painted in white or yellow on a dark ground or in black on a light ground. They are also to be carefully cut in or centre-punched on the sides of iron and steel ships, and on wood ships they are to be cut into the planking for at least 3 mm. The marks are to be plainly visible, and, if necessary, special arrangements are to be made for this purpose.

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# LLOYD'S REGISTER OF SHIPPING

*November, 1964*

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Telegraphic Address :
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*Overseas:* COMMITTEE, LONDON, E.C.3
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Telephone No. 5-3627 Telegrams: Janbar, Perth

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H. B. Gratte

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Telephone No. Warrawong J2200 Telegrams:

*Ship and Engineer Surveyor* ... ... ... I. M. Petrie

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Telegrams: Register, Whyalla, South Australia

*Ship and Engineer Surveyor...* ... ... K. T. Fitchett

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PRINCIPAL SURVEYOR FOR NEW ZEALAND ... ... F. E. TURPIE (Resident at Wellington)

**WELLINGTON,** *with New Plymouth and Napier*

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# LLOYD'S REGISTER OF SHIPPING

## Rules and Regulations for the Construction and Classification of Steel Ships, 1965. Notice No. 1

(Distribution: All holders of Steel Ship Rules and Extracts Nos. 1, 2, 3, 4, 5, 6 and 8)

**NOTICE IS HEREBY GIVEN** THAT AT MEETINGS OF THE GENERAL COMMITTEE, HELD ON THE 5TH NOVEMBER AND 10TH DECEMBER, 1964 AND THE 28TH JANUARY, 1965, THE FOLLOWING ADDITIONS AND AMENDMENTS WERE MADE TO THE SOCIETY'S RULES AND REGULATIONS FOR THE CONSTRUCTION AND CLASSIFICATION OF STEEL SHIPS.

THE AMENDMENTS TO PARAGRAPH 262 OF CHAPTER E (PUMPING AND PIPING) AND PARAGRAPHS 201 AND 202 AND THE NEW PARAGRAPH 206 OF CHAPTER F (FIRE PROTECTION, DETECTION AND EXTINCTION) COME INTO FORCE ON THE 26TH MAY, 1965, CONSEQUENT UPON THE RATIFICATION OF THE 1960 SAFETY OF LIFE AT SEA CONVENTION.

71, FENCHURCH STREET, LONDON, E.C.3